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CORROSION OF BOILER TUBES IN THE UNITED STATES NAVY.

BY LIEUTENANT COMMANDER WALTER F. WORTHINGTON, U. S. NAVY.

(Continued.)

The experiments described in the August and November numbers of the JOURNAL were continued as before, all of the pieces being weighed again before going into the tank. No. 2 showed a loss of weight of two grammes since its last removal from the tank, and Nos. 1, 3, 4, 7, 8, 10, 11, 13, 14 and 15 a loss of one gramme, no doubt due to inaccuracies in weighing and to the fact that some of the rust was rubbed off in handling. No. 6 shows a reduction of area of $4\frac{1}{2}$ square inches due to a $\frac{3}{8}$ strip having been cut off for analysis, as stated on page 910 of the JOURNAL for November, and a corresponding reduction of weight of 45 grammes.

During the third period of sixteen weeks, the water in the tank was carefully tested every week with fresh blue litmus paper, but no trace of acid could be discovered. At the end of the period

the pieces were removed, cleaned with a brush but not scraped, then weighed.

Table No. V shows the areas and weights of the pieces just before they were put into the tank and just after they were taken out.

The losses of weight per square inch for each of the two preceding periods of sixteen weeks' exposure are also inserted for convenience of reference.

Referring to the table, it is seen that in every instance the rate of corrosion has been less during the third period than it was during the second period. It is also evident that each nickel-steel plate has its own rate of corrosion; the tube represented by samples Nos. 3 and 4 has another rate, while the tube represented by Nos. 5 and 6 has a third, and the tube represented by Nos. 7 and 8 has a fourth characteristic rate.

As far as loss of weight is concerned, the lap-welded steel and iron are remarkably equal and occupy a position intermediate between the best and worst samples of seamless-drawn tubes.

Since these samples have been exposed for forty-eight weeks, and their positions in the tank shifted every week, it is impossible for tube manufacturers to mantain any longer that all of their tubes are of equally good quality and that all the difference in the life time of a set of tubes is due to the manner in which they are cared for on shipboard, to their location in the boiler, or to accidental causes.

It would also appear that as far as corrodibility in fresh water is concerned, and where no galvanic action is possible, a Bessemer steel tube, of the quality used in the experiments, will probably last as long as any other kind.

Referring to the photographs, it is seen that the corrosion has gone on principally in the same spots, the ellipses and circles referred to in the November number of the JOURNAL as visible on sample No. 3 are now seen on samples Nos. 3, 4, 7 and 8, and are more numerous; the pit marks on Nos. 5 and 6 are deeper and more numerous; the pit marks on Nos. 9, 10, 11, and 12 are numerous and deep inside and out, while Nos. 13, 14, 15 and 16 are marked in the same manner but to a perceptibly less extent.

TABLE V.—SHOWING LOSS OF WEIGHT OF SAMPLES OF STEEL AND IRON AFTER FORTY-EIGHT WEEKS' EXPOSURE TO AIR AND DISTILLED WATER.

Number of sample.	Kind of material.	Total area.	Weight at beginning of third sixteen weeks, November 8, 1900.	Weight at end of third sixteen weeks, February 28, 1901.	Total loss during third sixteen weeks.	Loss per square inch during third sixteen weeks.	Loss per square inch during second sixteen weeks.	Loss per square inch during first sixteen weeks.	Remarks.
		Sq. ins.	*Grammes.*	*Grammes.*	*Grammes.*	*Grammes.*	*Grammes.*	*Grammes.*	
1	Nickel-steel	55.40	250	248	2	.036	.072	.053	Bent hot.
2	....do	56.40	254	251	3	.053	.071	.106	Bent cold.
3	Solid cold-drawn O. H. steel	40.88	376	368	8	.196	.244	.342	Samples from one tube.
4	....do	43.18	385	376	9	.208	.277	.301	
5	....do	53.62	500	493	7	.131	.149	.149	Samples from one tube.
*6	....do	48.36	456	450	6	.124	.151	.132	
7	....do	56.57	423	410	13	.230	.282	.298	Samples from one tube.
8	....do	57.00	464	449	15	.263	.281	.332	
9	Lap-welded Bessemer steel	57.00	439	426	13	.228	.281	.244	All from one maker.
10	....do	57.00	450	439	11	.193	.263	.210	
11	....do	57.00	487	476	11	.193	.281	.228	
12	....do	57.00	443	431	12	.211	.281	.228	
13	Lap-welded iron	51.72	411	401	10	.193	.271	.251	All from one maker.
14	....do	55.83	432	421	11	.197	.269	.241	
15	....do	56.24	438	425	13	.231	.267	.266	
16	....do	57.06	458	445	13	.228	.280	.262	

*NOTE 1.—A piece 3/8-inch wide was cut from this sample for analysis, hence the area and weight is less by 4½ square inches and 45 grammes than those given in table IV.

NOTE 2.—The discrepancy of 2 grammes in the case of sample No. 2, and 1 gramme in samples 1, 3, 4, 7, 8, 10, 11, 13, 14, 15 between weights given in tables IV and V, is probably due to inaccuracy in weighing and to rust knocked off when the pieces were handled.

As stated last November, a second attempt was made by one of the leading experts in this country to get good photo-micrographs of the metal of samples Nos. 1, 4, 7, 9 and 14, but he found it very difficult, and the results were only a partial success, the photographs proving not very clear.

For the benefit of the uninitiated it may be said that the method of getting such photographs is as follows: The metal is first highly polished, leaving a surface perfectly free from scratches. This surface is slightly etched with some suitable corrosive fluid and then put under a microscope, so arranged that the magnified image can be photographed. In the case in question, the image was magnified five hundred and forty times.

The photo-micrographs of samples Nos. 1 and 4 are very much alike, while the photograph of No. 7 is much more like No. 9 than it is like No. 4.

The principal differences between the appearance of the metal of Nos. 9 and 14 is that in the latter case, as might have been expected, a large piece of slag is seen.

While it would undoubtedly be interesting and instructive to continue the experiments until at least some of the pieces are corroded through, the writer considers that the results so far recorded prove that there is a radical difference in the quality of tubes when exposed to conditions as nearly equal in every respect as would ever be practicable in a boiler. The most pressing need now, from the engineer's point of view, is to discover what can be done to stop, or check corrosion, and the next series of experiments will be directed to that end.

For the manufacturer, the best course to pursue would be to get samples which differ widely in their manner of corrosion and to have numerous photo-micrographs taken, grouping those from the best samples apart from those of the worst samples, and also separating those taken from metal in the wake of the pit marks from those taken in other parts of the same piece. It is probable that some difference would be found in the photographs which would throw light on the cause of the trouble. A manufacturer would have the tube business all in his own hands if he could discover a method of turning out tubes like samples Nos.

FIG. 1.

FIG. 2.

FIG. 3.

FIG. 4.

FIG. 5.

FIG. 6.

FIG. 7.

FIG. 8.

FIG. 9.

FIG. 10.

FIG. 11.

FIG. 12.

FIG. 13.

FIG. 14.

FIG. 15.

FIG. 16.

3 and 4, which after nearly a year's exposure to corrosive influences would emerge with a silvery, smooth surface, shining as if it had been newly galvanized, and if he could at the same time guarantee that none of his tubes exposed to the same influences and for the same length of time would be deeply pitted and drilled like samples Nos. 5 and 6.

THE STRENGTH OF U. S. STANDARD BOLTS.

By Mr. Harvey D. Williams.

The table of strengths of standard bolts heretofore in use by the Bureau of Steam Engineering having proved inadequate, a revision was undertaken by the writer acting under the direction of Lieutenant Commander F. H. Bailey, U. S. Navy. The following article is prepared and offered to the Journal with the view of placing on record the method of procedure followed in constructing the new table.

It is first necessary to find an expression for the torque that results from screwing up the bolt in terms of the load, pitch, diameter, etc. To this end let

d = effective diameter of bolt.

δ = mean diameter of thread = $\frac{1}{2}$ (nominal diameter + d).

p = pitch in inches = 1 ÷ number of threads per inch.

P = useful load in pounds acting in the direction of the length of the bolt.

μ = coefficient of friction.

$M = Q\frac{\delta}{2}$ = twisting moment, or torque in inch pounds.

Suppose the thread to be of square section, and let one turn of the thread be developed into a wedge. From the dimensions of this wedge and the notation assumed above, we have the following:

	Force × { Distance overcome } = { Work done.		
Resistance, ...	P	p	Pp
Power (at right angles to P), .	Q	$\pi\delta$	$Q\pi\delta$
Friction (in direction of P), .	$P\mu$	$\pi\delta$	$P\mu\pi\delta$
Friction (in direction of Q), .	$Q\mu$	p	$Q\mu p$

In the act of driving the wedge, or screwing up the bolt, the driving force Q overcomes a resistance which is made up of the three other items, hence

$$Q\pi\delta = Pp + Q\mu p + P\mu\pi\delta,$$

which reduces to

$$Q = P\frac{p + \mu\pi\delta}{\pi\delta - \mu p}.*$$

The value of the coefficient of friction μ under average conditions is about .15, and with U. S. standard (60°) threads the actual friction is greater than with square threads in the proportion of $2 \div \sqrt{3} : 1 = 1.155 : 1$. Substituting these values and the value of π, our equation becomes

$$Q = P\frac{p + .544\delta}{3.1416\delta - .173p}.$$

This applied to the ¼-inch bolt, where $\delta = .2175$ inch and $p = .05$ inch, gives us $Q = .2496P$ and $M = .027144P$. The value of the constant in the last equation is now calculated for the entire series of U. S. standard bolts.

Our investigation up to this point may be summarized as follows: In applying to a bolt the useful load P, by screwing up its nut, there is necessarily applied at the same time the torque M, the value of which, in terms of P, we have calculated separately for each size of standard bolts.

We have now to derive an expression for the fiber stress induced in the bolt by the combined action of the direct load P and the torque M. The load P produces a longitudinal tensile stress of $t = 4P \div \pi d^2$, and the torque M produces a transverse shearing stress of $s = 16M \div \pi d^3$. From the theory of elasticity we have for the resultant fiber stress

$$f = \frac{3}{8}t + \frac{5}{8}\sqrt{t^2 + 4s^2}.\dagger$$

* Unwin, Ed. 1898, p. 149.

† Lanza, Ed. 1886, p. 693.

Substituting the values of t and s, this reduces to

$$f = \frac{P}{2\pi d^2}\left\{3 + 5\sqrt{1 + \left(\frac{8M}{Pd}\right)^2}\right\}.$$

The useful fiber stress, or that portion of f which contributes toward the support of the useful load P, is

$$f' = \frac{4P}{\pi d^2}.$$

The efficiency of the bolt is then

$$\frac{f'}{f} = 8 \div \left\{3 + 5\sqrt{1 + \left(\frac{8M}{Pd}\right)^2}\right\}.$$

By means of this equation and the values of M already determined, the efficiency is now calculated for all sizes of U. S. standard bolts. Thus the efficiency of the $\frac{1}{4}$-inch bolt is 74.68 per cent., the meaning of which is that a load applied to a $\frac{1}{4}$-inch bolt by means of its nut produces a stress about one-third greater than would result if the same load were applied by hanging on a weight.

The efficiency of each size having been thus determined, it is an easy matter to construct the accompanying table. The efficiency is given in the table to four significant figures, it being the value from which all other values in the table are computed. The factor of safety equals the direct load factor 7, divided by the efficiency, and the safe loads given in the body of the table correspond to the factor of safety in the same horizontal line and the ultimate strength at the head of the column.

To facilitate the computation of bolts having threads which are finer or coarser than the standard, the column headed "relative fineness of thread" is given, in explanation of which it only needs to be remarked that the relative fineness of thread equals the number of threads per inch multiplied by the diameter, and that bolts of different sizes but having the same relative fineness of thread will have the same efficiency and the same factor of safety. As the thread is made relatively finer and finer beyond the limits of the table, the corresponding efficiency approaches 88.06 per cent. as a limiting value, beyond which it cannot go.

SAFE LOADS FOR U. S. STANDARD BOLTS.

Relative fineness of thread.	Nominal diameter of bolt.	Number of threads per inch.	Efficiency. $\frac{f'}{f}$ %	Factor of safety. $\frac{7}{\frac{f'}{f}}$	Ultimate strength. 20,000 — Alloy. Cu. 88%, Sn. 10%, Zn. 2%	40,000 — Phosphor bronze.	50,000 — Wrought iron and best rolled bronze.	60,000 — Class B bolt material.	65,000 — Class A bolt material.	80,000 — Class A, Nos. 1 and 2, machinery forgings.	95,000 — High grade machinery forgings.
5	¼	20	74.68	9.4	57	115	143	172	186	229	272
	5/16	18	76.56	9.1	99	198	247	297	322	396	470
6		16	77.49	9	150	301	376	451	488	601	714
	7/16	14	78.38	8.9	207	415	519	623	675	830	986
6.5	½	13	78.48	8.9	282	564	704	845	915	1,125	1,340
	9/16	12	78.92	8.9	365	730	912	1,095	1,186	1,460	1,730
		11	79.11	8.8	456	913	1,140	1,370	1,480	1,820	2,170
7.5	5/8	10	80.00	8.8	690	1,380	1,725	2,070	2,240	2,760	3,280
		9	80.48	8.7	964	1,930	2,410	2,900	3,140	3,860	4,580
8	¾	8	80.61	8.7	1,265	2,530	3,170	3,800	4,120	5,060	6,010
	1	7	80.48	8.7	1,595	3,190	3,990	4,790	5,180	6,380	7,570
	1⅛	7	81.37	8.6	2,070	4,140	5,180	6,210	6,730	8,280	9,830
	1¼	6	80.92	8.7	2,440	4,890	6,110	7,330	7,940	9,780	11,600
9	1⅜	6	81.61	8.6	3,020	6,040	7,540	9,060	9,800	12,050	14,300
	1½	5½	81.56	8.6	3,530	7,060	8,820	10,600	11,500	14,100	16,750
	1⅝	5	81.37	8.6	4,060	8,120	10,150	12,200	13,200	16,200	19,250
	1¾	5	81.92	8.5	4,800	9,600	12,000	14,400	15,600	19,200	22,800
9	2	4½	81.61	8.6	5,360	10,750	13,400	16,100	17,400	21,500	25,500
	2¼	4½	82.43	8.5	7,120	14,200	17,800	21,400	23,100	28,500	33,800
10	2½	4	82.35	8.5	8,750	17,500	21,900	26,300	28,400	35,000	41,500
11	2¾	4	83.20	8.4	11,000	22,000	27,500	33,000	35,700	44,000	52,200
12	3	4	83.42	8.4	13,400	26,800	33,500	40,200	43,600	53,600	63,600
13	3¼	4	83.88	8.3	16,100	32,200	40,200	48,400	52,400	64,400	76,400
14	3½	4	84.20	8.3	19,000	38,100	47,600	57,200	61,900	76,200	90,400
15	3¾	4	84.47	8.3	22,200	44,500	55,600	66,700	72,300	89,000	105,500
16	4	4	84.71	8.3	25,700	51,400	64,200	77,000	83,400	102,800	122,000
17	4¼	4	84.91	8.2	29,350	58,700	73,400	88,100	95,400	117,400	139,300
18	4½	4	85.09	8.2	33,300	66,600	83,200	100,000	108,000	133,000	158,000
19	4¾	4	85.26	8.2	37,400	75,000	93,700	112,000	122,000	150,000	178,000
20	5	4	85.44	8.2	41,900	83,800	105,000	126,000	136,000	167,500	199,000
21	5¼	4	85.55	8.2	46,600	93,200	116,500	140,000	151,000	186,000	221,000
22	5½	4	85.68	8.2	51,500	103,000	129,000	154,500	167,000	206,000	244,500
23	5¾	4	85.80	8.2	56,700	113,500	142,000	170,000	184,000	227,000	269,000
24	6	4	85.92	8.1	62,000	124,000	155,000	186,000	202,000	248,000	295,000

The factor of safety, meantime, approaches the limiting value, 7.95.

The efficiency of a hollow bolt is always greater than that of a solid bolt of the same diameter and number of threads, the limiting efficiency for a very fine thread on a very thin tube being 96.48 per cent., as against 88.06 per cent. for a solid bolt. The error will therefore be always on the safe side if we use the efficiencies and factors of safety given in the table in computing hollow bolts.

TEST OF A CONDENSER AND EVAPORATOR.

The following official report of the test of a condenser and evaporator, the invention of Captain John Ericsson, is interesting from an historical point of view. It is contributed by Mr. Charles H. Haswell.

NEW YORK, *October 31, 1847.*

SIR: In acceptance of your invitation of the 17th ultimo, we, the undersigned, had the honor to meet together in the City of New York, with the view of testing and reporting upon an apparatus invented by Captain John Ericsson, for the purpose of supplying the boilers of marine steam engines with a continuous supply of fresh water, and applied by him under your direction in the U. S. Revenue Steamer *Legaré.*

We have now respectfully to report, that on the 23d ultimo we embarked in the *Legaré* at 12 M., proceeded to sea, and remained on board till the following morning. During this time, the boiler was in operation 15 hours, and we had ample opportunity of examining the means employed for supplying it with water and the results produced.

By the ordinary method of condensing steam in marine navigation, boilers are supplied with the *water of condensation*, composed of the steam that is withdrawn from the boiler and the necessary quantity of salt water required for its condensation. Hence a boiler in operation is constantly parting with steam (fresh water) and receiving salt water in exchange. The effect of this operation, uninfluenced by a correction, would be, that in a few hours a degree of saturation of the water in the boiler would be reached that would precipitate upon the plates of the furnaces and flues a scale of sufficient thickness to arrest the passage of the heat to the surrounding water and cause the destruction of the plates, by exposing them to a temperature destructive of their tenacity. The correction in use is the removal

of the water as it approaches saturation, and is effected by *blowing* or *pumping off*.

In the operation of either of these methods it is apparent that there is a loss of the heat that has been imparted to the water blown or pumped off, that neglect to open or shut the blow-off cock, or in the admission of the required supply of water, involves the duration of the boiler and may, as it frequently does, involve the lives of the passengers and crew and the safety of the vessel. Even when all practicable attention is given to blowing-off, salt scale will be deposited in long voyages, particularly in the middle latitudes, and accumulate to an extent that renders its removal imperatively necessary. This is at all times a difficult, and even under the most favorable circumstances, an imperfect operation, and when this deposit coats the surfaces of the flues, the consumption of fuel is increased to an extent unsuited to the economy of mercantile enterprize and to the duration of operation requisite for naval purposes.

This evil may be avoided by furnishing the boilers with a full supply of fresh water, and as the weight could not be accommodated nor the space spared in a vessel for an instrument and its fuel for the sole purpose of distilling the quantity required, it is obvious that the steam furnished by a boiler must be returned to it, after being condensed by the radiation of its heat to cold surfaces, and not by the admixture of water. This method was *proposed* by James Watt, so early as the year 1776, and has been effected to some extent by an instrument invented by Mr. Samuel Hall, of England, and applied to the engines of many steam vessels, in some of which, notwithstanding its imperfections, it is yet used. It has failed, however, to answer the full purposes desired and anticipated.

In the arrangement of Mr. Hall a great number of thin metal tubes, from one-half to three-fourths of an inch in diameter, were placed *vertically* in a condenser, and exposed to a current of cold water from the sea, and into which the steam from the cylinder was admitted, for the abstraction of its heat by the radiation of it to the water without the tubes. Now it is evident, that by this arrangement the condensed steam would run down the inner

surface of the tubes, in its passage presenting a non-conducting lining to them, and in its collection at their bottom an obstacle to the current of the steam and a diminution of the effective radiating surface.

With this method of condensation it will be perceived that this instrument provides alone for returning to the boiler the water that has passed through the engine as steam. It follows, then, that all escapes of steam from the boiler or engine or water-leaks from the boiler, pipes, etc., must be replaced by distillation, at an expense of fuel, directly as the evaporation. Further, continued use of this instrument, exhibited an oleaginous deposit upon the inner surface of the tubes from the use of oil and tallow in the steam cylinder and on the valve faces, which, acting as a non-conductor, materially obstructed the condensation of the steam.

The apparatus of Captain Ericsson was designed to obviate the difficulties and deficiencies developed in that of Mr. Hall, and is composed of two distinct instruments, a condenser and an evaporator; the first for the purpose of condensation, and the latter for a supply of fresh water to provide for any losses of steam or water from the boiler by escapes, leaks, gage vents, etc., etc.

The condenser is a cylindrical vessel set at a slight inclination from a horizontal line, containing the requisite extent of radiating surface in metal tubes of *two inches* bore, with an open space at each end. By this arrangement there is free space for the current of steam to pass and for the condensed steam to run down the lower side of the tubes, without presenting a lining of water to intercept radiation or an obstruction to the course of the steam. Connected with this is a pump, by which water from the sea is drawn in and forced through the spaces between the tubes and the inner surface of the shell of the condenser. Thus the latent heat of the steam is absorbed by contact with the tubes, and condensation is effected for the double purpose of affording a vacuum for the engine and of restoring fresh water to the boiler, for continuous evaporation and condensation, to meet the requirements of the engine.

The evaporator, as constructed, is a parallelopipedon with a semi-cylindrical top and bottom, the lower portion of which is occupied by a number of tubes similar to those in the condenser, which communicate with a valve at each end of the steam cylinder, worked by the engine. Around these tubes, and for some distance above them, water from the sea is admitted for the purpose of being evaporated, and the space above this water is open to the condenser and consequently *in vacuo*. This instrument being designed to furnish fresh water to replace that which may be lost, its operation is resorted to only as occasion may require, and is effected in the following manner: when the piston is near the termination of its stroke the valve referred to opens (above or below, as the case may be), and closes when the piston begins its return stroke; by this arrangement steam is withdrawn from the engine that has very nearly performed its full expansion effect, and passing into the tubes of the evaporator its heat is absorbed by the water surrounding them, and as this water is *in vacuo* it readily boils at a low temperature, and its vapor, being led to the tubes in the condenser, it is condensed with the steam from the cylinder and is supplied to the boiler.

Upon the experimental trial to which you were pleased to request our attention all practicable arrangements for correct observations were entered into; and with a view to acquire full and progressive notes of the operations of the apparatus, the observations of the various points were confided to special committees, which, upon the conclusion of the trial, reported full notes for furnishing the following, viz:

The boiler was filled with fresh water from above the opening of the blow-off cock; below this, salt water had been left, from an impression of its effect being too inconsiderable to authorize its removal.

At the commencement of the operation of the engine, the water in the boiler as indicated by a saline hydrometer, when at a temperature of 150 degrees Fahrenheit, was $.\frac{6}{32}$ *

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* $\frac{12}{32}$ being the point of saturation of water when at a temperature of 200 degrees.

The highest temperature of the *feed water* observed was 158 degrees Fahrenheit.

The lowest, 132 degrees, and the average, 150 degrees.

The highest *vacuum* observed was from 16 to 18 inches.

The lowest from 11 to 15, and the average was from 12 to 15 inches.

The highest *steam pressure* was 54 pounds mercurial gage.

The lowest was 20 pounds, and the average was 48.6 pounds.

The highest number of *revolutions* was 47 per minute.

The lowest number was 30, and the average 42.3.

The point of cutting off was at three-eighths of the stroke.

The temperature of the sea water was 57 degrees.

Duration of *operation* of the engine and boiler, 14 hours and 20 minutes. Time during which steam was raised, 20 hours.

Dimensions of Engine, &c.

Cylinder.—36 inches in diameter, with a stroke of piston of 32 inches.

Boiler.—1,400 square feet of heating surface.

Condenser.—637 square feet of radiating surface.

Evaporator.—100 square feet of heating surface.

Upon coming to, the freshness of the water was again tested, and when at a temperature of 150 degrees by a different thermometer than that used at the first operation (it having been broken in the interim) the hydrometer indicated $\frac{7}{32}\frac{5}{2}$; whether this difference in the indications is to be attributed to a change in the density of the water or to a difference in the thermometers, they being of different manufactures, we are unable to decide; fortunately the difference is quite inconsiderable, and is not regarded as deserving of further consideration.

So soon as the temperature of the condenser was reduced to a degree that rendered an examination of it practicable, one of its heads was removed in our presence, and the tubes, when examined, were entirely free from any deposits or incrustation upon their surfaces, and the opinion is entertained, that at a temperature of feed water commensurate with economy of fuel,

any difficulty from the deposit of oleaginous matter in this instrument is not to be apprehended.

Regarding the particular performances of the condenser and evaporator, it appeared that Captain Ericsson had relied too confidently on a general current of the cold water through the former instrument, whereas the current was quite partial, being but directly through its narrowest part, the sides of it; hence, the upper portion of it was almost inoperative. This feature was clearly developed by the application of a hand along the surface—while the effect of it was apparent in the moderate condensation indicated by an attached mercurial gage.

Of the evaporator, its capacity was clearly shown, in the facility with which the level of the water in the boiler could be raised through the space between two gage cocks, and by a resort to its operation not being necessary for more than one-tenth of the time.

Immediately after the close of this trial measures were taken to effect a diffused operation of the cold water, and as diaphragms could not be introduced between the tubes to alter the current of the water, without incurring an impracticable delay, the expedient of causing the steam to circulate through the tubes was resorted to, and was effected by the application of diaphragms in the open space at each end of the tubes. Upon the completion of this, a further trial was had on Friday, the 1st instant, when several observations furnished the following:

Pressure of steam, . .	50	pounds mercurial gage.
Revolutions, . . .	47	per minute.
Vacuum, ...	20.5	inches.
Temperature of feed water,	150	degrees Fahrenheit.
Temperature of sea water,	62	degrees Fahrenheit.

Compared with the ordinary method of condensation, the value of the method observed is determined by an investigation and consideration of the following points, viz: Evaporation, pressures, consumption of fuel, safety and duration of the boiler.

I. EVAPORATION. *Ordinary Method.*

Temperature of feed water, 100 degrees Fahrenheit.

Temperature of sensible and latent heats of steam,	1192°
Deduct temperature of feed water, ...	100°
Heat to be added, ...	1092°

New Method.

Temperature of feed water, 150 degrees Fahrenheit.

Temperature of sensible and latent heats, . .	1192°
Deduct temperature of feed water, ...	150°
Heat to be added, ...	1042°

Then $\frac{1042}{1092} = \frac{.954}{1.}$ which represents a gain in the evaporating temperature in the new method of 4.56 per cent.

2. PRESSURES. *Odinary Method.*

Pressure of steam—mercurial gage, . . .	50 lbs.
Vacuum, 28 inches, ...	= 13.7 lbs.
	63.7 lbs.

Cut-off at three-eighths of the stroke.

Effective pressure on the piston, . .	= 47 lbs.

New Method.

Pressure of steam, ...	50 lbs.
Vacuum, 20.5 inches, ...	= 10 lbs.
	60 lbs.
Effective pressure on the piston, ...	44.5 lbs.

Then $\frac{47}{44.5} = \frac{1.05}{1.}$ which represents a loss in pressure by the new method of 5 per cent.

3. CONSUMPTION OF FUEL. *Ordinary Method.*

In the Gulf of Mexico and between the Tropics it is necessary to blow off when a hydrometer constructed similar to the one

already referred to indicates $\frac{2}{32}$; in the Northern and Southern Atlantic and Pacific oceans, when it indicates $\frac{2.5}{32}$. Hence $\frac{2.+2.5}{2} = 2.25$, the average point for blowing off.

As the average degree of saturation of feed water is $\frac{.75}{32}$, the quantity of water blown off compared to that fed to a boiler is as .75 to 2.25, which is in the proportion of 1 to 3.

Temperature of the water blown off at the pressure and degree of saturation given, . . .	290°
Deduct temperature of feed water, . . .	100°
Temperature lost by blowing off, ...	190°
As the heat to be added for the purpose of evaporation is 1092°—	
$1092 \times 3 \sim 1$, the proportion of feed water evaporated, ... =	2184°
And $190 \times 3 \sim 2$, the proportion of feed water blown off, ... =	190°
The heat absorbed, is	2374°

Then $\frac{190}{2374} = \frac{.08}{1.00}$, which represents the loss of heat by blowing off in the ordinary method of 8 per cent.

SUMMARY OF RESULTS.

Gain by evaporation, ...	4.56	per cent.
Gain by consumption of fuel, . . .	8.	"
	12.56	"
Loss by pressures, ...	5.	"
Total, ...	7.56	"

Which is a saving in the expenditure of heat, affording a like economy in the consumption of fuel and altogether independent of the loss of heat, by the presence of scale in a boiler when salt water is used, and from leaks incurred by the oxidizing effects of salt water.

With the *Ordinary Method*, the level of the water in a boiler

is constantly varying from one or both of the following causes, viz: the quantity of the water blown off, or the particular extent of opening of the feed valve; while the effective operation of the feed pump and neglect of the blow-off valve involves the burning or an explosion of the boiler.

With the *New Method*, these operations are set aside, thus blowing off is unnecessary and the supply to the boiler being first obtained from it, the transit being immediate and the communication incapable of restriction (for if the condensed water was not taken off by the feed pump the condenser would choke and become inoperative,) there can be no decrease in the level of the water other than that arising from leaks of water and steam. Further, the use of fresh water in a boiler will extend the term of its duration from three and five years to seven and nine.

With a further modification of the condenser, establishing a more diffused current of the cold water, it is evident that a full vacuum may be obtained, as the practicability of attaining this end by external condensation has long since been developed, and with a less proportion of radiating surface than is exposed in the instrument referred to. From the analysis, however, here given regarding pressures and temperatures, it would appear that a full vacuum, with corresponding reduction of the temperature of the feed water is not authorized, and as such departure from the hitherto practice furnishes the temperature necessary to prevent any oleaginous deposit upon the surface of the tubes of the condenser, practice and utility are in desired harmony.

A very effective and economical element in steam navigation arises with the operation of this new method, from the absence of scale in the boiler, the presence of which is unavoidable where salt water is used, and to avoid the formation of it as far as practicable, other than a low temperature and corresponding pressure are precluded by the waste of fuel and injury to the boiler consequent upon the existence of this scale, acting as a new conductor of the heat to the water—whereas, with the use of fresh water, higher pressures can be worked and economy of fuel attained in an increased expansion of the steam.

Reviewing the facts herein presented, we are of the opinion

that the operation of the apparatus of Captain Ericsson, as far as developed, was eminently successful, and that, with the modification of the condenser suggested, a higher degree of vacuum can be readily obtained. In view of the very great importance of the successful introduction of this method of condensation in the merchant and naval services, we recommend to your consideration the propriety of sending the *Legaré* on a distant cruise, for the purpose of developing the advantages of the apparatus by continued and extended use.

Apprised of the ready attention you have given to this important subject, and the zealous interest you have manifested in its development, we cannot but congratulate ourselves and the profession with which we are connected, that you have seen fit to test this improvement by the construction of the apparatus on which we have been called to report. Such encouragement identifies in the merits of success the patron with the improvement, and is honorable to yourself no less than the nation in whose service you have bestowed it.

We have the honor to be,

Very respectfully,

Your obedient servants,

CHAS. H. HASWELL, *Engineer-in-Chief U. S. N.*
JAS. J. MAPES, *New York.*
LEWIS TAWS, *Philadelphia.*
JAMES MCFARLAN, *Union Ferry Co., N. Y.*
J. H. TOWNE, *Philadelphia.*
WM. SEWELL, JR., } *Chief Engineers U. S. N.*
WM. W. W. WOOD, }

To the Honorable ROBERT J. WALKER,
Secretary of the Treasury,
Washington, D. C.

INTERIM REPORT OF THE BOILER COMMITTEE APPOINTED BY THE BRITISH ADMIRALTY.

COPY OF THE LETTER OF INSTRUCTIONS SENT TO THE PRESIDENT.

Admiralty, S. W., 6th September, 1900.

SIR: I am commanded by my Lords Commissioners of the Admiralty to inform you that they are pleased to nominate you as Chairman of a Committee which they have decided to appoint for the purpose of considering certain questions arising in connection with the use of various modern types of boilers for naval purposes, as set forth in the terms of reference specified in the succeeding paragraphs of this letter.

(2.) In addition to yourself, the Committee will be composed of the following members:

Mr. J. A. Smith (Inspector of Machinery, R. N.).

Mr. John List, R. N. R. (Superintending Engineer, "Castle" Line).

Mr. James Bain, R. N. R. (Superintending Engineer "Cunard" Line).

Mr. J. T. Milton (Chief Engineer-Surveyor of Lloyd's Register of Shipping).

Professor A. B. W. Kennedy.

Mr. J. Inglis, LL.D. (Head of the firm of Messrs. A. and J. Inglis, Engineers and Shipbuilders, Pointhouse, Glasgow).

Commander Montague E. Browning, R. N., and Chief Engineer William H. Wood, R. N., will act as Joint Secretaries to the Committee.

(3.) The points which it is desired that the Committee should investigate and report upon are as follows:

(*a*.) To ascertain practically and experimentally the relative advantages and disadvantages of the Belleville boiler for naval purposes as compared with the cylindrical boiler.

(*b.*) To investigate the causes of the defects which have occurred in these boilers and in the machinery of ships fitted with them, and to report how far they are preventable either by modifications of details or by difference of treatment, and how far they are inherent in the system. The Committee should also report generally on the suitability of the propelling and auxiliary machinery fitted in recent war vessels and offer any suggestions for improvement, the effect as regards weight and space of any alterations proposed being stated.

(*c.*) To report on the advantages and disadvantages of the Niclausse and Babcock and Wilcox boilers compared with the Belleville as far as the means at the disposal of the Committee permit, and also to report whether any other description of boiler has sufficient advantages over the Belleville or the other two types above mentioned, as a boiler for large cruisers and battleships, to make it advisable to fit it in any of Her Majesty's ships for trial.

(4.) For the purpose of making direct experiments between ships fitted with Belleville and cylindrical boilers respectively, the *Hyacinth*, fitted with Belleville boilers, will be placed at the disposal of the Committee as soon as the crew have been sufficiently trained and such trials have been carried out as to ensure that the machinery is in efficient order. A cruiser of similar type fitted with cylindrical boilers will also be placed at the disposal of the Committee when required, for the purposes of comparison.

(5.) For the investigation of defects, copies of the reports of all the defects of machinery and boilers which occurred during the recent naval maneuvers will be placed before the Committee, and they will be able to inspect ships specially commissioned for the maneuvers, which include the *Ariadne* and *Gladiator* with Belleville boilers, and the *Perseus* and *Prometheus* with Thornycroft boilers, with any others that may have returned to any of the home ports.

(6.) The *Europa* is now on passage from Australia, and it is desired that, at a suitable time, an investigation into the causes of her high coal expenditure and machinery defects shall be con-

ducted under the directions of the Committee, and that she shall afterwards be put through such trials as the Committee think necessary.

(7.) Information on any special points connected with the behavior of the boilers or machinery of water-tube boiler ships on ordinary peace service which the Committee may desire to have will be obtained by the Admiralty from any of Her Majesty's ships in commission, and opportunities can be taken when the Channel Squadron is in any of the home ports to examine the boilers and machinery of the *Niobe*, *Diadem*, *Arrogant* and *Furious*, which have Belleville boilers, and the *Pactolus*, which is fitted with Blechynden boilers.

(8.) The *Pelorus*, fitted with Normand boilers, which has recently returned from three years' continuous service in the Channel Squadron and at the Cape of Good Hope, and the *Powerful*, will be available for examination during their refits.

(9.) The *Sharpshooter*, fitted with Belleville boilers without economizers, the *Seagull*, fitted with Niclausse, and the *Sheldrake*, with Babcock and Wilcox boilers, will be employed in training stokers and will be available for examination, and, if necessary, for any comparative experiments between these boilers that the Committee may wish to make, though the comparatively low pressure for which the machinery of these vessels was designed makes it impossible to try these boilers under the conditions under which they would work if fitted in a new ship.

(10.) It is particularly desired that any conclusions the Committee may arrive at should be supported by experimental proof as far as possible, and that the Committee should propose any further experiments they think necessary for this purpose.

I am, sir, your obedient servant,

EVAN MACGREGOR, *Secretary.*

Vice-Admiral SIR COMPTON DOMVILE, K. C. B.

COPY OF LETTER ASKING FOR AN INTERIM REPORT.

Admiralty, S. W., 4th January, 1901.

SIR: I am commanded by my Lords Commissioners of the Admiralty to inform you that they will be glad to have an in-

terim report from the Boiler Committee, as soon as possible, on any of the points referred to the Committee on which they consider they have collected sufficient evidence or experimental proof to enable them to form a reliable opinion.

The questions to which my Lords especially desire an answer are the following:

(1.) With the experience and information which have already been obtained, can it be stated whether water-tube boilers are considered by the Committee to be more suitable than cylindrical boilers for naval purposes?

(2.) Should the answer to the above question be in the affirmative, do the Committee consider that the Belleville boiler has such an advantage over other types of water-tube boilers as to lead them to recommend it as that best adapted to the requirement of H. M. Navy?

(3.) Generally, having regard to the importance of deciding on the types of boilers to be provided for vessels which are ordered in the immediate future, are the Committee prepared at present to make any recommendations, or to offer any suggestions on the extent to which any particular type or types of boilers should be fitted in new vessels?

Whilst their Lordships are anxious to receive an interim report at as early a date as practicable, they in no way wish to press the Committee for a premature expression of opinion.

I may add that any report made should be accompanied by full particulars of all the evidence and experimental data on which the recommendations of the Committee are based.

I am, sir, your obedient servant,

EVAN MACGREGOR.

THE SECRETARY, BOILER COMMITTEE.

Admiralty, 19th February, 1901.

BOILER COMMITTEE.

SIR: I have now the honor to submit for their Lordships' information the *ad interim* Report called for by their letter S. 315/407 of the 4th January, 1901, on the three questions to which the attention of the Committee was especially directed, viz:

"(1.) With the experience and information which have already been obtained, can it be stated whether water-tube boilers are considered by the Committee to be more suitable than cylindrical boilers for naval purposes?

"(2.) Should the answer to the above question be in the affirmative, do the Committee consider that the Belleville boiler has such an advantage over other types of water-tube boilers as to lead them to recommend it as that best adapted to the requirement of H. M. Navy?

"(3.) Generally, having regard to the importance of deciding on the types of boilers to be provided for vessels which are ordered in the immediate future, are the Committee prepared at present to make any recommendations or to offer any suggestions on the extent to which any particular type or types of boilers should be fitted in new vessels?"

The replies to these questions are given in the first three paragraphs of the Report, and the reasons for the replies in the remaining paragraphs, with all the advice the Committee are at present able to give on the subject of the future boiler for the navy, with suggestions for trying two new types of boiler as quickly as possible.

The Report is unanimous with the exception of Mr. J. A. Smith, Inspector of Machinery, who, though agreeing with the tenor of the Report as a whole, explains that, in his opinion, the Bellevile boiler will give satisfactory results when carefully treated, and considers there is no necessity for delaying the progress of ships already designed for them.

In conclusion, I should like to bring to their Lordships' notice the great zeal and trouble taken by the civilian members of this Committee to attend the meetings and trials necessary to form an opinion on this question, often at great inconvenience to themselves, being all busy men with their own special work to do.

I have the honor to be, sir, your obedient servant,

COMPTON DOMVILE, *Vice-Admiral,*
President, Boiler Committee.

THE SECRETARY OF THE ADMIRALTY.

AD INTERIM REPORT.

(1.) The Committee are of opinion that the advantages of water-tube boilers for naval purposes are so great, chiefly from the military point of view, that, provided a satisfactory type of water-tube boiler be adopted, it would be more suitable for use in His Majesty's Navy than the cylindrical type of boiler.

(2.) The Committee do not consider that the Belleville boiler has any such advantage over other types of water-tube boilers as to lead them to recommend it as the best adapted to the requirements of His Majesty's Navy.

(3.) The Committee recommend:

(*a.*) As regards ships which are to be ordered in the future: That Belleville boilers be not fitted in any case.

(*b.*) As regards ships recently ordered, for which the work done on the boilers is not too far advanced: That Belleville boilers be not fitted.

(*c.*) As regards ships under construction, for which the work is so far advanced that any alteration of type of boiler would delay the completion of the ships: That Belleville boilers be retained.

(*d.*) As regards completed ships: That Belleville boilers be retained as fitted.

(4.) In addition to the Belleville type of boiler, the Committee have had under consideration four types of large straight-tube boilers which have been tried in war vessels, and are now being adopted on an extended scale in foreign navies. These are:

(*a.*) The Babcock and Wilcox boiler.

(*b.*) The Niclausse boiler.

(*c.*) The Dürr boiler.

(*d.*) The Yarrow large-tube boiler.

(*a*) and (*b*) have also been tried in our own Navy with satisfactory results, and are now being adopted on a limited scale.

If a type of water-tube boiler has to be decided on at once for use in the Navy, the Committee suggest that some or all of these types be taken.

(5.) The Committee recommend that the completion of the two sloops and the second-class cruiser fitting with Babcock

and Wilcox boilers, and the sloop and first-class cruiser fitting with Niclausse boilers, be expedited, in order that the value of these types of boilers for naval purposes may be ascertained at the earliest possible date. This is especially important, as the Babcock and Wilcox boiler adopted in the ships under construction differs materially from the Babcock and Wilcox boiler as fitted in the *Sheldrake*.

(6.) The Committee recommend that boilers of the Dürr and of a modified Yarrow type be made and tested at the earliest possible date, under their supervision, with a view of aiding the selection of one or more types of water-tube boilers for use in His Majesty's ships. For this purpose the Committee suggest that two cruisers, not smaller than the *Medea* class, with vertical triple-expansion engines, be placed at their disposal, and that they be empowered to order, at once, Dürr and Yarrow boilers to be fitted to them, and to order also the removal of their present boilers and the necessary modifications to their machinery, so that the performance of the types of boilers named may be definitely ascertained under ordinary working conditions from extended seagoing trials. The Committee suggest vessels not smaller than the *Medea* class, because the evidence before them shows that it has been difficult to draw from Torpedo Gunboat trials conclusions fully applicable to larger vessels.

(7.) With reference to paragraph (1), evidence has been given before the Committee to the effect that three most important requirements from the military point of view are:

(*a*.) Rapidity of raising steam and of increasing the number of boilers at work.

(*b*.) Reduction to a minimum of danger to the ship from damage to boilers from shot or shell.

(*c*.) Possibility of removing damaged boilers and replacing them by new boilers in a very short time and without opening up the decks or removing fixtures of the hull.

These requirements are met by the water-tube boiler in a greater degree than by the cylindrical boiler, and are considered by the Committee of such importance as to outweigh the advantages of the latter type in economy of fuel and cost of up-keep.

(8.) The opinion expressed by the Committee in paragraph (2) has been formed after a personal examination of the boilers in a number of His Majesty's ships, including the *Diadem*, *Niobe*, *Europa*, *Hermes*, *Powerful*, *Furious* and *Ariadne*; upon the statements of defects which have been placed before them; and the evidence of the Chief Engineers of those vessels and other officers on the Engineering Staff of the Admiralty and Dockyards. This evidence is being printed, and will be forwarded when ready.

(9.) The Committee consider the following points in relation to the construction and working of the Belleville boiler to constitute practical objections of a serious nature:

(*a.*) The circulation of water is defective and uncertain, because of the resistance offered by the great length of tube between the feed and steam collectors, the friction of the junction boxes, and the small holes in the nipples between the feed collector and the generator tubes, which also are liable to be obstructed, and may thus become a source of danger.

(*b.*) The necessity of an automatic feeding apparatus of a delicate and complicated kind.

(*c.*) The great excess of the pressure required in the feed pipes and pumps over the boiler pressure.

(*d.*) The considerable necessary excess of boiler pressure over the working pressure at the engines.

(*e.*) The water gages not indicating with certainty the amount of water in the boiler. This has led to serious accidents.

(*f.*) The quantity of water which the boiler contains at different rates of combustion varying, although the same level may be shown on the water gages.

(*g.*) The necessity of providing separators with automatic blow-out valves on the main steam pipes to provide for water thrown out of the boilers when speed is suddenly increased.

(*h.*) The constant trouble and loss of water resulting from the nickel sleeve joints connecting the elements to the feed collectors.

(*i.*) The liability of the upper generator tubes to fail by pitting or corrosion, and, in economizer boilers, the still greater liability of the economizer tubes to fail from the same cause.

Further:

(*k.*) The upkeep of the Belleville boiler has so far proved to be more costly than that of cylindrical boilers; in the opinion of the Committee this excess is likely to increase materially with the age of the boilers.

(*l.*) The additional evaporating plant required with Belleville boilers, and their greater coal consumption on ordinary service as compared with cylindrical boilers, has hitherto nullified to a great extent the saving of weight effected by their adoption, and, in considering the radius of action, it is doubtful whether any real advantage has been gained. The Committee are not prepared without further experience to say to what extent this may not apply to other types of water-tube boilers.

(10.) At the time the Belleville boiler was introduced into the Navy in the *Powerful* and *Terrible*, it was the only large-tube type of water-tube boiler which had been tried at sea on a considerable scale, under ordinary working conditions. The Committee therefore consider that there was justification for then regarding it as the most suitable type of water-tube boiler for the Navy.

(11.) To obtain satisfactory results in the working of the Belleville boiler, in face of the defects named in paragraph (9), more than ordinary experience and skill are required on the part of the engine-room staff. It appears, however, from the evidence placed before the Committee, that the engineer officers in charge of Belleville boilers have not been made acquainted with the best method of working the boilers, and that which experience has shown to be most effectual in preventing the pitting and corrosion of tubes.

(12.) In view of the rapid deterioration of economizer tubes in several vessels, the Committee have specially considered whether the extra power per ton of boiler at high rates of combustion, obtained by the use of economizers, has not been too dearly purchased. The evidence before them indicates that at the lower and more usual rates of combustion the *Powerful* type of boiler has given results as satisfactory as the economizer type. It is at the same time less complex, and free from the special risks of tube deterioration which have proved so serious in many cases,

notably in the *Europa*. They therefore recommend, for ships under construction, that the non-economizer type should be reverted to where practicable, with the tubes raised higher above the firebars to increase the combustion space, and that where possible the steam collectors should be made larger, and more accessible internally.

(13.) The evidence before the Committee shows that a large proportion of the coal expended in the Navy is used for distilling and other auxiliary purposes, in harbor as well as at sea. For such purposes, the cylindrical boiler is, in the opinion of the Committee, more suitable and economical than any type of water-tube boiler. They recognize that there are objections to fitting cylindrical and water-tube boilers in combination, but they believe that those drawbacks would be more than compensated for by resulting advantages, observing that the cylindrical boilers could be used for supplying distilled water in case of failure or insufficiency of the evaporating plant. On these grounds, it is considered desirable that all the new vessels of large power should be provided with cylindrical boilers to do the auxiliary work.

(14.) The Committee have to state, for the information of their Lordships, that a series of comparative trials for determining economy in coal and water consumption were arranged in October, 1900, for His Majesty's ships *Minerva* and *Hyacinth*. The trials of the former ship commenced on January 7, as soon as she was ready, but were temporarily interrupted by recent events. The Committee are, however, now informed that the *Minerva* will not be again available until after March 2, and that the *Hyacinth* will not be ready to commence her trials until the first week in April. It is proposed to include in these trials a full-speed run for both ships from Portsmouth to Gibraltar and back.

COMPTON DOMVILE, *Vice-Admiral and Chairman.*
JAS. BAIN.
JOHN INGLIS.
ALEX. B. W. KENNEDY.
JOHN LIST.
J. T. MILTON.
M. E. BROWNING, } *Joint Secretaries.*
WM. H. WOOD, }

I concur with the above report, except as regards paragraph 3, and on the point dealt with in that paragraph my report is as follows:

(1.) Although the Belleville boiler has certain undesirable features, I am satisfied, from considerable personal experience, and from the evidence of engineer officers who have had charge of boilers of this type in commissioned ships, that it is a good steam generator, which will give satisfactory results when it is kept in good order and worked with the required care and skill.

I am also satisfied from my inspection of the boilers of the Messageries Maritimes Company's S. S. *Laos*, after the vessel had been employed on regular mail service between Marseilles and Yokohama for more than three years without having been once laid up for repairs, that with proper precaution, the excessive corrosive decay of the tubes which has occurred in some instances can be effectually guarded against.

(2.) Having in view the extent to which Belleville boilers have already been adopted for His Majesty's ships, and the fact that there are now three or four other types of water-tube boilers which promise at least equally good results, I am of opinion that, pending the issue of the final report of the Committee, Belleville boilers should not be included in future designs. At the same time, I see no necessity for delaying the progress of ships which have been designed for Belleville boilers in order to substitute another type of boiler.

JOS. A. SMITH.

The report has been received by the English press as a conclusive argument against further use of the Belleville boiler, but the Admiralty has rather adopted the views of Mr. J. A. Smith, as is evidenced by the following remarks of Mr. Arnold-Forster, Parliamentary Secretary to the Admiralty, made in the House of Commons:

"No blame could attach to the Committee for having issued an interim report. No doubt the report was incomplete, but this was not the fault of the Committee. The First Lord put no pressure on the Committee. He asked the Committee whether, in view of the meeting of the House, they were in a

position to make an interim report which would guide the representatives of the Admiralty. There were two issues to decide. The honorable member for Gateshead (Mr. W. Allan) would have no water-tube boilers at all; the Committee said 'Let us have water-tube boilers, but not of this type;' and then there was the opinion of every advisory board of nearly every navy in the world—Germany, France, the United States, Japan, Russia, Italy—all taking a view diametrically opposed to the honorable member for Gateshead. Speaking as representative of the Admiralty, he was bound to take the view that water-tube boilers should be adopted. As to the type, there were some who advocated the removal of the Belleville boilers, but that was not the view of the Admiralty. He did not say that the Belleville boiler was the best, but it had been regularly doing excellent work. The *Ocean*, the *Andromeda* and the *Diadem* had efficiently steamed long distances with these boilers. Much depended on the manipulation of the boilers, and no effort was being spared to train stokers to manipulate them. The existing Belleville boilers could not be replaced by cylindrical boilers without sacrifice of speed and efficiency. His belief was that the example which had been set by Germany and the United States was one which we might follow without great fear. All reasonable men would be persuaded that the Admiralty were taking the right course in regard to the boilers. They refused to delay the completion of any ship, but they would put water-tube boilers in any ship in which they could be put without delaying its construction. They would reserve alterations in existing ships until they had evidence to guide them. They could not destroy the efficiency of some twenty ships until they were clear that it was absolutely essential in the interest of the Navy to do so. If it was necessary to alter any of the ships, it would be necessary to withdraw them one by one and put them in the hands of the dockyard officers."

As indicating that the views of the Committee are not generally accepted as conclusive may be inferred from the following letter of Sir E. J. Reed, published in the "London Times" of March 22d:

TO THE EDITOR OF THE TIMES:

Sir: A temporary affection of the throat prevents me from speaking before Easter in the House of Commons, and I have, therefore, to request your permission to allow me to offer in your columns a few remarks upon the above report, dealing with it mainly from a Parliamentary and economical point of view.

I would preface my remarks by saying that, although six or seven years ago I spoke occasionally in the House of Commons in defense of Belleville boilers against extravagant attacks, and although I have successfully employed them in one very important warship and elsewhere, I have not only never been an advocate of their wholesale adoption, but have on several occasions freely criticised some of their features, and when advising the Government two years ago respecting the boilers best suited for the transport *Hardinge* gave the preference to a Scotch boiler with Howden's forced draft for the Royal Marine of India.

It must be remembered, however, that for many years past the Belleville boiler has been employed in the British Navy on a very extensive scale; that it is this boiler on which most of our modern warships of first-class importance depend for their life and movement; that it is so employed with very marked success in many of them; and that it is at the present moment being supplied to many others. The most ordinary prudence and common sense would, therefore, suggest that the gentlemen entrusted by the King and Parliament with the responsibilities of the Naval Service, while attending, as they are bound to attend, to all reasonable adverse criticism, would so deal with the matter as to bring to bear upon it the most complete and perfect knowledge of the subject, and the largest possible practical experience of Belleville boilers both on trial and on sea service. It is due to Parliament, who place their trust in the Admiralty, and to the country, which has to depend upon Parliament in the matter, that any committee appointed to investigate and report upon it should be both competent and impartial—impartial, I mean, not merely in respect of any possible interested bias, but impartial in that far larger and loftier sense which

implies freedom from such bias as one long round of uniform and restricted experience so fatally imposes upon nearly all men.

It was not to such a committee, I am sorry to say, that Lord Goschen committed this boiler inquiry. The question at issue being essentially of such a nature as only men more or less closely acquainted with the Engineer Service of the Royal Navy could deal with thoroughly, Lord Goschen appointed one engineer, and one alone, of all the competent Royal Naval engineers within his reach, the other engineering members—five in number—being men able and experienced in mercantile engineering practice beyond all doubt or question, but every one of them devoid of that very special experience which is absolutely essential to a full and effective grasp of the subject. It was all very well, all very noble even, no doubt, for Lord Goschen to set these merchant-engineers, so to speak, with their great and intimate knowledge of merchant and passenger steam machinery, loose into the Admiralty domain, to gather *en amateur*, such information as they could collect; but, as Mr. Milton, one of its ablest members, said in March, 1899, at the Institution of Civil Engineers, after enumerating the requirements of the machinery for merchant ships, "In war vessels, however, very different conditions exist." On observing the appointment of the Committee in September last, I remarked to an engineering friend, "That committee will be certain to report adversely to the Belleville boiler, for its members will have to get all their information at second hand, and will chiefly examine those men in whose hands that boiler has failed."

I would next point out that Lord Selborne, whom we must, I presume, consider responsible for the letter of January 4, 1901, in which this interim report was called for, changed the substantial part of the inquiry very materially. Lord Goschen very properly, as I think, instructed the Committee to inquire "whether any other description of boiler has sufficient advantages over the Belleville or the other two types above mentioned as a boiler for large cruisers and battleships to make it advisable to fit it in any of her Majesty's ships for trial"—a perfectly unex-

ceptionable instruction. Lord Goschen evidently bore in mind the fact that, in order to displace the Belleville boiler (with which so much valuable experience was being gained, and which was becoming so much better understood and used), the new boiler, whatever it might be, would have to prove that it possessed substantial advantages over the Belleville. But Lord Selborne, being a new hand, and apparently without any deep sense of responsibility in the matter, reversed the whole position, and asked whether "the Belleville boiler has such an advantage over other types of water-tube boilers as to lead them to recommend it as that best adapted to the requirements of the Navy"—which seems to me to imply that this form of boiler, whatever its merits, is to be got rid of unless it is considered superior to all its rivals. I do not, as a member of Parliament and a taxpayer, think this is quite the attitude for the head of the British Navy to assume in a matter in which it would be so easy for him to spread throughout the Navy and in other countries unmerited and unlimited distrust in a very large number of His Majesty's ships.

The Committee, however, have followed this lead, and have roundly advised "that Belleville boilers be not fitted in any case" as regards future ships, and "as regards ships recently ordered for which work done on the boilers is not too far advanced." This seems so satisfactory to Lord Selborne that he has hurried this interim report into the hands of Parliament in what I fear impartial persons will regard as a rather unseemly manner; for the report itself contains no grounds for the advice given. Lord Selborne himself can hardly be unaware of the unseemliness of this proceeding, for in the letter of January 4, the Secretary to the Admiralty said, "any report made should be accompanied by full particulars of all the evidence and experimental *data* on which the recommendations of the Committee are based." This the Committee have not attended to. Instead of full particulars of everything, they give no particulars whatever of anything, and this crude report has been put before Parliament without a basis of any kind. It will, no doubt, even in that condition, go far towards bringing the heavy labors of Lord Selborne's pre-

decessors and present officers under severe public censure—mainly, I am bound to say, as undeserved as it is unsubstantiated.

The report itself is one of the most singular documents that I have ever read—so singular as to be accounted for only by the fact that the Admiralty's determination "to have an interim report from the Boiler Committee as soon as possible" overbore the sense of the Committee. The first question which the new and anxious Admiralty wanted answered as soon as possible was—If the Committee was able yet to state whether they preferred water-tube boilers to the old cylindrical boilers? The idea of the British Admiralty being eager to get—for publication as we now know—an answer to this elementary question!

But even this question the mainly-mercantile-engineering Committee, coming so freshly to a subject so novel to most of them, have not been able to answer decisively; they only say that, "provided a satisfactory type of water-tube boiler be adopted, it would be more suitable for use in His Majesty's Navy than the cylindrical type of boiler." This almost looks as if the Committee well knew, but hardly liked to name, "a satisfactory type." That is not the case, however; they know of several types, as the report afterwards shows; they even mention four types, and they say, "if a type of water-tube boiler has to be decided upon at once for use in the Navy, the Committee suggests that some or all of these types be taken." Why do they make this suggestion? Why recommend "some or all of these types?" Is it because they know that all these types are better than the Belleville, which they seek to put a stop to? Not at all; they know that two of the types—the Babcock and Wilcox boiler and the Niclausse—have been tried in foreign navies and also in our own Navy with satisfactory results so far as the trials have gone, and are being actually adopted on a limited scale. But so far are they from being satisfied as to their further success that they urge the Admiralty to press on with certain trials with these boilers "in order that the value of those types of boilers for naval purposes may be ascertained at the earliest possible date." So that this Committee, framing its interim report under the pressure of Lord Selborne, in one sentence tells his lordship that if a

decision be necessary they may take certain types of boilers at once, but in the very next sentence urge that a trial of these very boilers should be made quickly in order to ascertain their value for naval purposes! Why do the Committee recommend the Admiralty to adopt certain types of boilers of the naval value of which they are manifestly ignorant?

But there are two other types of the four recommended for immediate adoption—viz: the Dürr and a modified Yarrow boiler. Having recommended the adoption of these, or either of them, if immediate decision be necessary, do they go on to give us the grounds for their advice? Do they even show that they have good grounds for giving it? Not at all; so far from this, they go on actually to recommend the Admiralty to take out of two of His Majesty's cruisers their cylindrical or ordinary boilers and fit boilers of the Dürr and Yarrow types, "with a view of aiding the selection of one or more types of water-tube boilers for use in His Majesty's ships." So they first advise the Admiralty to select these boilers, and then to enter upon a very costly and prolonged experimental enterprize for the express purpose of ascertaining if they ought to be selected!

But perhaps the most amazing part of the report is the Committee's enumeration, in clause 9, of what they regard as "practical objections" to the Belleville boilers. With all respect to the professional gentlemen signing the report, I must say that this summary is the most curious instance of joint professional co-operation that I have ever seen. Some of their points are common to all water-tube boilers; some of them, where defects existed, have already been corrected; some of them do not exist in the recent Belleville practice of the Admiralty; and some of them—such as the objection to the use of "separators"—are beneficial additions to high-pressure boilers, whether Belleville or other. Such a clause as No. 9 could not possibly have been signed by any engineer well experienced in the use of Belleville boilers.

The fear of encroaching too much upon your space compels me to restrict my commentaries. I hope it will be understood, however, that it is from no excessive partiality whatever to the Belleville boiler, and from no kind or degree of antagonism to

the other types of boiler favored by the Committee, that I seek thus to abate the ardor shown by our new First Lord in the work of breaking down the confidence of the country and of the world at large in this important element of naval strength. When we found it necessary to pass from the heavy and water-weighted cylindrical boiler to the water-tube type, the Belleville was, as this Committee themselves state, "the only large-tube type of water-tube boiler which had been tried at sea on a considerable scale, under ordinary conditions," and "there was justification for then regarding it as the most suitable type of water-tube boiler for the Navy." Its enlarged use has been attended by several breakdowns, and no wonder, considering its great novelty, our inexperience in its manufacture, the equal inexperience in its use of those on board His Majesty's ships, and the number of things connected with all water-tube boilers which had to be found out. It is also to be remembered that we have been greatly increasing our Navy of late years, and with it the demands for naval engineers and stokers, and that we have been compelled to entrust these perfectly novel and somewhat complex boilers to the hands of men who had never seen such boilers before, and whom it was next to impossible to instruct in their use. It would be idle to deny that even the best and highest of the Admiralty engineers had much to learn in respect of the materials and methods of manufacture which the various parts of these boilers made necessary. The mere production of efficient tubes has been a costly problem, the burden of which has fallen heavily upon the manufacturers as well as upon the admiralty; the prevention of deposits in the tubes has been another anxious problem, but one which has now, I believe, been finally solved; and there is no doubt whatever that even our most competent and skilful engineers have had their talents taxed to the utmost by these novel difficulties.

But, great as may have been the troubles which beset this new branch of naval work from a scientific point of view, I cannot doubt that the "human element" has been a very grave cause of the breakdowns, such as they have been. Certain it is that there are many ships in our own and other navies supplied with

Belleville boilers in which no sort of danger or difficulty has ever been experienced. The Japanese have had warship after warship of the largest classes fitted with Belleville boilers, and no complaint has ever been made of them. They are fitted in the powerful Chilian cruiser *O'Higgins*, and her trials out of Newcastle were made under the most disadvantageous circumstances, the English stokers striking for more pay on the very morning of the first trials. But Chilian stokers who happened to be on board, took the boilers in hand, and her two-days' trials were completed without difficulty of any kind. That ship, during three years of service, has since steamed 30,000 miles, often at the highest speed, and never has had a single tube burst or burn or prove bad. The only difficulty that has ever occurred with her boilers was a small one, clearly arose from neglect, and was in no way special to the type of boiler. Very bad accidents and very numerous injuries may readily occur when novel boilers have to be adopted on a large scale. But experience has taught me to believe that perfect management is as necessary as a perfect machine. Bad or mistaken management may break down any machine, and it is idle, where one machine answers well and another precisely like it fails, to attribute the failure to the machine, or to anything else than the management. The Belleville boilers of the Japanese, Chilian and other foreign ships, which never break down or give trouble, are precisely like those of our ships which have broken down; and in such a case it is not difficult to conjecture the cause of our failure. It is even less difficult when we remember that so many of our own Belleville boilers in the Royal Navy are worked on service with complete success.

In this letter I am offering no objection to the trials of the Babcock and Wilcox, Niclausse and Yarrow large-tube boilers. I am glad to see some of them tried, and have little doubt of their success. I have a strong liking for the Yarrow boiler in particular, and, where there is no objection to the use of forced draft, it will, with reasonable care, be perfectly successful. I differ from the Committee in thinking that any costly experi-

ments, involving long delays, are necessary before largely adopting this boiler.

What I object to, and most strongly object to, and what the guardians of the public purse in Parliament must be careful about, is the advice of the Committee to interfere with contracts already in hand. They guard themselves by advising the Admiralty to deal only with cases "for which the work done on the boilers is not too far advanced," but if they thoroughly understood the question they would know that wherever the work upon any of these types of boiler has been advanced at all it is not available for boilers of a wholly different type. Some of the materials might be so available, but there is no "work done" which can be. They, therefore, open up a dangerous vista of prospective expense by their suggestive interference with existing contracts.

I conclude by deprecating in the strongest manner the expenditure of additional public money upon any of the suggestions of this crude interim report, which rests upon no adduced basis of facts, and which is of a tendency most injurious to the Navy and the country. It produces an array of "practical objections of a serious nature" in relation to the construction and working of the Belleville boiler, most of which I regard in an engineering sense as almost childish; but in spite of these "serious" objections they approve of the original adoption of the boiler by the Admiralty; they approve of its retention in all completed ships; and they approve of its retention in all ships where the work is far advanced. But outside of these conditions they would put a sudden stop to its use. Why? Because "they do not consider that the Belleville boiler has any such advantage over other types as to lead them to recommend it as the best adapted to the requirements of His Majesty's Navy." Then, what is the best? This the Committee does not say, and does not know. All it says is, "Take any of four other types of boiler, and go ahead with them in all the cases which have to be decided on at once." They prudently do not say "Suspend all your ships now under construction or order while we find out which is a better boiler than the Belleville;" but they do virtually say,

"We do not know at present for certain any better boiler than the Belleville, but we advise you to adopt some other or others, and when you have made your contracts, and have committed the country to the new expenditure, we will make experiments to find out whether you have decided wisely or not."

There is one advantage to set against the many grave disadvantages of the premature publication of this interim report; Parliament and the country will see very clearly the necessity for putting some check upon the present Board of Admiralty. The Army administration may be bad, and the House of Lords has certainly been the arena lately of sorry spectacles; but can the Army show anything comparable to this Admiralty imbroglio? That great administrator, Lord Goschen, before quitting office, flung off the responsibility for his own enormous adoption of Belleville boilers by appointing a Committee of men mostly utterly ignorant of the working of such boilers, or of any other boilers in the Royal Navy, and left the country at the mercy of this Committee. Lord Goschen's successor urges the Committee not to wait for the result of their full inquiries, but to get an interim report in "as soon as possible," giving full particulars of the grounds of any opinions they may have formed. An interim report is sent in by the Committee without any such particulars, expressing opinions upon the main questions put to them, without waiting to complete their investigations; and this crude production is thrust before Parliament and the country without delay, and for the express and obvious purpose of casting the utmost discredit possible upon almost the only boilers that have been ordered by the Admiralty for years past. If the Admiralty adopt this report and proceed upon the lines of this Committee's advice, they will abdicate their primary functions, spread the most appalling distrust throughout the Naval Service, absolve the engineers and stokers of His Majesty's ships from their bounden duty to make boilers which work well in other ships work well in theirs, and make us the laughing-stock of the world.

The interim report is valueless, and very much worse than that, able in other engineering spheres as its members undoubtedly are. Admiral Sir Compton Domvile (chairman), in a letter

enclosing the document, brought to notice "the great zeal and trouble taken by the civilian members of the Committee to attend the meetings and trials necessary to form an opinion on the question, often at great inconvenience to themselves, being all busy men, with their own special work to do." Just so; but how can these busy men, with their own special work to do—special work lying far away from that of working water-tube boilers in ships of war—how can they, by means of fitful attendances at meetings and by attending occasional trials, have obtained a mastery over this most intricate matter, and acquired the knowledge necessary for the overthrow of the whole boiler work of the Admiralty itself for many years past? Having had myself to deal professionally and responsibly with many Belleville and other forms of water-tube boilers, I find the interim report an incoherent and an inconsistent document; and if the British Board of Admiralty should adopt and act upon it the failure of the Admiralty as an administrative body will exceed any failure that the Army can show to us.

I am, Sir, yours obediently,

E. J. REED.

Mr. Belleville has addressed a long letter to the Secretary of the Admiralty, in which he traverses each of the objections raised by the Committee against his boiler. He points out that it has been used for many years in the steamers of the Messageries Maritime and in the French Navy; that the circulation is all that could be desired; that automatic feed regulation is necessary with all water-tube boilers that contain a small quantity of water, and that the Belleville appartus is so satisfactory that some of the Messageries steamers have been run by it alone; that the excess of pressure in feed-pumps and pipes is necessary where a number of boilers are fed by the same pump; that reducing valves are almost a necessity with all types of water-tube boilers; that the water gages give a true indication of the volume of water in the boiler; that there is less liability of water being carried over in the Belleville than in other types of water-tube boiler; that trouble from leakage of the nickel

sleeve joints is unknown in Belleville boilers built in France, and that when these joints are properly made and the boiler properly cared for, there is no abnormal loss of feed water; that pitting of tubes is not peculiar to the Belleville boiler, but exists in all boilers when proper precautions are not taken to prevent it; and that these precautions were not taken by the engineers of the British Navy, notwithstanding the fact that precise instructions were furnished by the Belleville Company; that the cost of maintenance of the Belleville boiler is not great when it is properly constructed and cared for; that the water-tube boiler requires totally different management and treatment from that usual with fire-tube boilers, and that the space between the grate bars is too great in British ships, entailing a waste of fuel that is charged to the boiler.

In answer to questions put to him by the Admiralty regarding alterations in the design of boiler, he said that the economizer type is more economical of fuel than the ordinary type; that it is not desirable to increase the height between grate bars and tubes; and that the steam drum might be slightly increased, but that no special advantage would be derived from the change.

Bearing on this general subject, the paper by Assistant Engineer J. K. Robison, U. S. Navy, on "Tubulous Boilers in the French Navy," published in Volume VII of the JOURNAL; and the one by Mr. James Howden, in Volume VI, on "Comparative Merits of Cylindrical and Water-tube Boilers for Ocean Steamships," are specially pertinent.

The recommendations of the Committee have already been followed by the Admiralty in ordering the completion as soon as possible of the sloop *Espiegle*, of 1,400 I.H.P., fitted with Babcock and Wilcox boilers, and of the *Merlin* with Niclausse boilers. It has been decided to put Yarrow boilers of the large-tube type in the new battleship *Queen*, of 15,000 I.H.P.; Babcock and Wilcox in the sister ship, *Prince of Wales*, and in the first-class cruisers, *Berwick*, *Cumberland* and *Donegal*, of 22,000 I.H.P. each, and in the sloop *Odin* of 1,400 I.H.P.; and Dürr boilers in the *Encounter*, a second-class cruiser of 12,500 I.H.P. It had previously been

decided to put Niclausse boilers in the *Suffolk*, a first-class cruiser of 22,000 I.H.P.; and Babcock and Wilcox boilers in the *Challenger*, of 12,500 I.H.P.

Besides these, eight Dürr boilers have been ordered to be built in Germany for the cruiser *Medusa* at a cost of $94,720, exclusive of spare parts. The guarantee of the Dürr company is that these boilers shall, with an air pressure of 1½ inches of water, furnish 155,000 pounds of dry steam per hour from feed water at a temperature of 80 degrees Fahrenheit; 104,000 pounds with an air pressure of ½ inch, and 80,000 pounds with natural draft.

DETAILS OF CONSTRUCTION OF THE NICLAUSSE BOILER.

By Mr. Geo. B. Hartley, Associate.

The subject of water-tube boilers for marine purposes is a question which has been argued, pro and con, for some years, so whatever may be written at this time would simply mean a rehearsing of theories and facts already expounded, other than to say that developments in marine engineering during the past decade warrants the expression that the engine seems to have preceded the boilers. By this paradoxical remark is meant that the propelling machinery is here, and the question is, "How may the steam generator be made more efficient and economical?" thus enhancing the engines' capabilities. In the restricted space allowable for these purposes with regard to ship tonnage and displacement, the Scotch boiler, which still has many adherents, because, of its reliability, possesses too many disadvantages as regards weight, limited pressure, space required and the time necessary to develop the working pressure. This, with the large capacity embodied in one unit, the crippling of which would seriously cripple the ship, combined with the expenditure of time and money in making repairs, necessitated the producing of a radical change in steam generators. Thus the water-tube boiler has been evolved. In its inception this latter type proved crude in principle and design, which, while natural in the beginning, quickly served to produce several types that have overcome the many objections and limitations of the Scotch boiler. The navies of the world are being equipped with one or more of the various water-tube boilers of different character, each of which is being strongly advocated. Among this number the boiler known as the Niclausse is now assuming a frontal position in the deliberations of naval authori-

ties, resulting in the acceptance of this type of steam generator by the United States Navy Department for the battleship *Maine* and the monitor *Nevada*, as well as for several cruisers recently contracted for. The equipment of these ships with the Niclausse boiler would seem to demand a more extended knowledge of its design and mechanical construction by engineers generally, for the reason that only those who are directly interested have had an opportunity of becoming familiar with them. With this in view it is intended that the following should be purely a descriptive explanation of its mechanical construction, and not an argument on the benefits of the principles of steam generating that may be involved in the design; nor is a comparison with other boilers to be touched upon, as this latter is a subject which could only be comprehensive after a thorough knowledge of the construction of the Niclausse boiler is obtained, assuming that the several water-tube boilers of better known character are already understood by the reader.

Construction of Parts.

HEADERS.

These may be of malleable iron or pressed steel, consisting of a rectangular form. The side walls are corrugated, while the front and back of the headers have "bosses" or flanges for tube holes, and are also ribbed, thus making an exceedingly strong form. In addition to the strength imparted to the header by the corrugations, this construction also permits the tubes to be nested in staggered rows, thus baffling the current of gases in process of combustion.

Fig. 1 represents a header used in the design of large boilers, and may be made to contain from eighteen to twenty-four tubes, as required or permitted by space, head room and the necessary heating surfaces of different constructions.

Fig. 2 represents a type termed "combination header," which is adapted to smaller boilers, such as are required in small cruisers, torpedo boats and launches. Boilers with this header have been constructed in France for mechanical traction engines

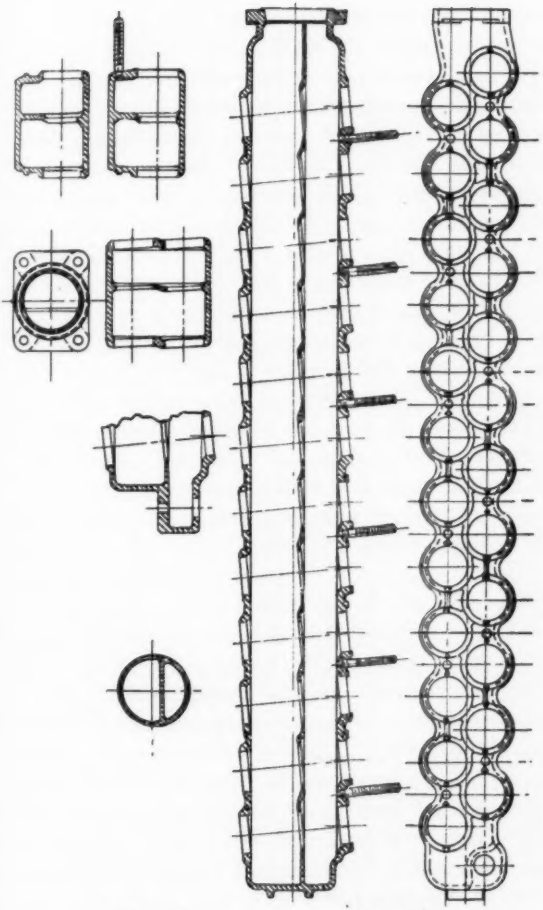


Fig. 1. Header.

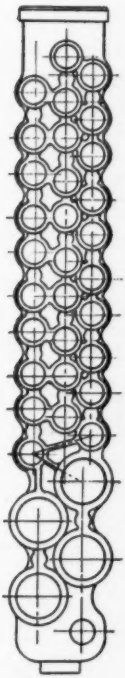


Fig. 2.
Combination
Header.

and automobiles. This is mentioned merely to show the diversified uses to which the Niclausse boiler is applicable.

The headers are divided into two compartments by a partition or diaphragm extending their full length, the purposes of which will be apparent later. The operation of machining the malleable-iron header consists of first cleaning the casting thoroughly of all foundry sand, and dressing smooth all irregularities on the surface where gates are broken off, etc., after which the thickness of the walls is carefully calipered to detect thin spots. Assuming the header to be satisfactory in these regards, it is then swung between centers in an ordinary lathe, and the true length of header determined by facing the top flange and cutting off the necessary amount from the foot pieces, which are cast sufficiciently long to allow for variations in the castings due to shrinkage, etc. In obtaining this length it is essential that the corrugations of all headers bear the same relation to their finished length, that all headers may have the correct adjustment when assembled. The large hole at top of header is bored on the same lathe, the finished hole being cone-shaped, one inch deep from faced-off top of casting, and having an angle of ten degrees. We now have established the correct length of header and machined the top cone hole.

It is next put in a boring mill of ordinary type, possessing no special features other than that it is strong and compact, insuring little vibration or spring. The header is placed on a movable carriage in an inclined position, the top cone hole fitting on an elevated rest, the bottom end of the casting resting on the carriage itself. This gives the header an inclination which will bore the tube holes at an angle of six degrees to the axis of the header. The tube holes are cored, leaving considerable metal to be removed. This is done by a double adjustable fluted reamer on a spindle, so spaced that the lower blades, after passing through the top tube hole, bore the lower tube hole at the same time that the upper fluting is cutting out larger the top hole. This brings the tube holes to a cone shape within $\frac{1}{20}$ inch of their necessary size. The header is then taken from the machine and placed on trestles, one of which is so elevated as to still maintain the inclin-

ation of the holes in the header, and the holes are then reamed to the finished size by a pneumatic-driven reamer, swung loosely. The header is then placed in a horizontal position under a radial drill press, where the blow-off cone hole in the front side of the header and the blow-off cone-bolt hole in the rear side are drilled and reamed to their taper finishes. The header is then thoroughly cleaned up by rounding off all sharp edges, removing fins and burrs, and all remaining particles of sand blown off by air blast. The fully machined header now goes to the assembling blocks, where it is placed in a vertical position and is ready for the insertion of the tubes.

EVAPORATING TUBES.

These (Figs. 3 and 4) are of seamless, cold-drawn, low-carbon steel, the physical properties of which must show, according to present specifications, a minimum tensile strength of 47,000 pounds per square inch of test section, and an elongation of not less than 20 per cent. in a length of 8 inches; this in addition to

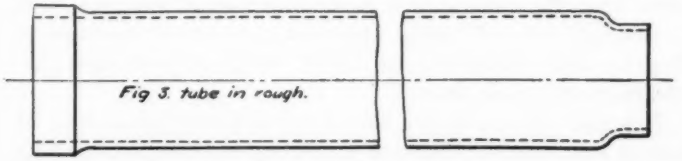


Fig 3. tube in rough.

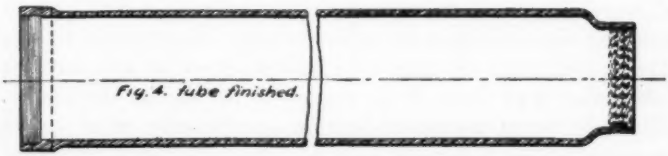


Fig. 4. tube finished.

the usual bending, crushing, flanging and hydrostatic tests required by many specifications and insisted upon by the Bureau of Steam Engineering of the United States Navy. The gage of tubes varies from No. 6 to No. 10 B.W.G., as may be specified. One end of the tube is solidly upset to afford additional thickness, or stock, for the turning off of a cone surface and the thread-

ing of the tube on the inside under the same. The other end (rear) is swaged down, which swaging must not reduce the thickness of the tube. The reducing of this end is for the purpose of making a thread on the outside on which to screw a back cap, as the diameter of this cap is slightly less when in place than the body of the tube.

The machining of this tube consists of two operations: First, it is put in a double-turret lathe, where the swaged-down end is threaded with sixteen threads to the inch. The outside diameter of the upset end is then turned off at an angle forming a cone within $\frac{1}{20}$ inch of the true size. The inside of the upset end is then tapped with left-handed threads, sixteen to the inch. The true length of the tube is determined by facing off the upset end. The tube now goes to what may be a termed a "grinding lathe," where between centers it revolves rapidly against a fine emery wheel revolving in an opposite direction, a fixed taper attachment on this machine bringing this emery wheel by micrometer measurements against the cone surface on the upset end of the tube until this surface is ground to the finished dimension determined by a gage. This method of developing the cone on the tubes brings about an absolute uniformity. Before taking the tube off the lathe the bearing cone edge is slightly rounded to prevent its cutting the tube hole when inserted to place in the header. The tube is now taken to the assembling table and clamped, ready to receive the lantern.

LANTERNS.

Figs. 5 and 6 represent the malleable-iron lantern, the machining of which consists in the rough lantern being clamped in a revolving chuck on a turret-headed lathe, with the large end out. The inner circle is then reamed and tapped with double threads, six to the inch. The angle of the tap used for these threads is decidedly abrupt. This insures the joint of the plug which fits here being made quickly, the extreme pitch of the threads preventing injury, and when the plug is screwed to place presenting broad thread-bearing surfaces. The lantern is then taken to another lathe where it is screwed on a plug center,

thus establishing an axis for the future machining of the lantern. The inner end is then turned off and threaded with a left-hand thread corresponding to the thread on the inner circle of the cone end of the tube mentioned above. Due care must be here taken to make this thread fit accurately and tightly when the lantern is screwed to place in the tube. The large end of the lantern is then turned off to a cone shape to within $\frac{1}{20}$ inch of the true size, after which it is taken to a grinding machine similar to that used for the tubes, where the cone is smoothly finished, the sharp edge of it being slightly rounded. The lantern now being fully machined, it is taken to the assembling table and screwed into the tube, which has previously been clamped to hold it while the lantern is being screwed to place.

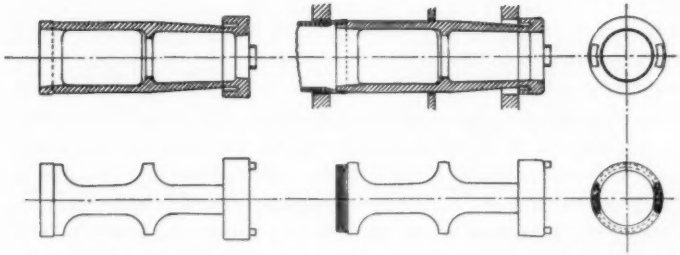


Fig. 5.
Lantern in rough.

Fig. 6.
Lantern finished.

White lead is used in making this joint. The lantern now becomes a part of the tube. It must be ascertained at this time that the cone on the tube and the cone on the lantern are the requisite distance apart, to the smallest fraction. The axis of the lantern and of the tube holes is the same, due to the method of machining both parts. It is to be noted that the lantern is bored or recessed under the cone to a sufficient depth to produce flexibility and permit the cone to be compressed, the necessity of which will be shown later. The tube and lantern now forming a unit, await the screwing on of the back cap to the swaged-down end.

BACK CAPS.

These (Fig. 7) are drop forgings, and are machined by being clamped in a revolving chuck on a turret-headed lathe, where the cap is reamed and counter-bored under the thread, to give clearance. It is then tapped with sixteen threads to the inch, care being taken to have this thread fit accurately. It is then taken to the tube and screwed in place on the swaged-down end. The evaporating tube is now complete in its entirety and is taken to the testing blocks, where the header has been previously bolted in a vertical position.

Before proceeding farther it may be mentioned that this work, while being done very accurately and uniformly, yet presents no

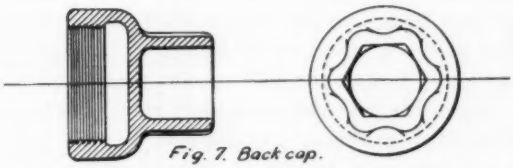


Fig. 7. Back cap.

difficulties whatever, nor care necessary beyond the ordinary machine-shop practice. No special tools have been required in the above operations, and all dimensions have been determined by the use of gages. It may be misjudged that work of this character, calling for absolute uniformity, requires undue skill on the part of the workmen, and special tools to produce accurate results. This is not true, however, as the system involved eliminates to a large degree errors of workmanship; each of the parts up to this time having been done by their respective workmen continuously, accomplishes results usually obtained through piece work.

FITTING UP OF ELEMENT.

Studs for the tube dogs having been screwed to place between tube holes as shown in Fig. 1, the tube holes in the header and the cones of the tube are covered with a non-corrosive mixture, the principal ingredient of which is graphite. This is of such

consistency as to permit its being applied with a brush. It does not lend any assistance, nor is it a necessary aid, in making the joint tight, but should always be used as a protection. The tube is then put into the tube holes in header and pushed back until the rear end has entered the cast-iron support. At this time the inner or tube cone has passed through the front and diaphragm holes so that it is at the point of entering its respective hole in the rear side of header. The cone on the lantern has already entered about $\frac{3}{16}$ inch, as illustrated by Fig. 9, which shows fully the principle and method of the cones making tight on the bearing surfaces of the holes in the header.

The tool for forcing the tubes tightly to their final bearings is now inserted and the tube forced in until the rear joint is made, the lantern cone compressing until this is accomplished. Both joints are now tight, and the diaphragm hole in the header is also closed by the partition of the lantern.

It is necessary to note the difference in the angles of all cone surfaces, that of the rear hole in header being 3 degrees 25 minutes, and of front of header 3 degrees 25 minutes. While the cone on the tube is 2 degrees 17 minutes, that of the lantern cone is 1 degree 25 minutes.

The ease and rapidity with which these joints are made is now apparent. The wrench used on the tool for forcing the tubes to place does not exceed 24 inches in length, which is mentioned as an additional proof of the ease with which this is effected.

On the opposite page is shown the inserting tool, in which

S is the spindle;

V a nut which screws against the dog clamp, which in turn forces the tube to place;

R the dog clamp;

E a T-piece which swivels on the end of *S*.

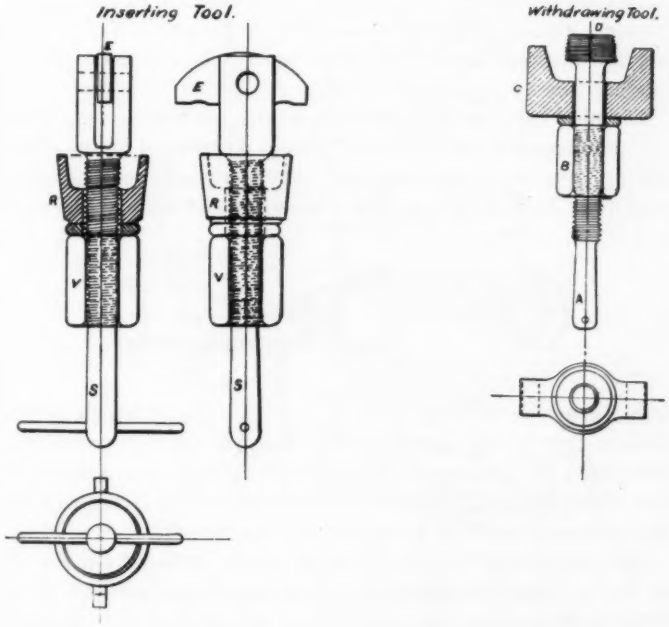
The operation is as follows: Insert the T-piece, *E*, through the lantern head and adjust it inside the face of the header; then turn the nut *V*, to the right until the tube is forced to its proper position.

In the withdrawing tool

A is the spindle;

B a nut that screws against the dog clamp, to withdraw tube;
C the dog clamp;
D a screw plug on end of spindle, which screws into lantern.

To operate it: Insert the screw plug *D*, into the end of the lantern and adjust the dog clamp on the header; then turn the nut *B*, to the right a part of a turn: the joint is broken, and the tube is then easily removed.



Assuming that all tubes have been placed in the header, and that it is desirable to change these tubes about by removing them and placing them in different header holes, this is accomplished as illustrated in Fig. 8. This is required by the naval inspector to demonstrate the absolute interchangeability of parts, which fact must be already apparent, as the tubes, after being machined,

are piled in lots containing from 500 to 1,000, and, in assembling, the element tubes are picked indiscriminately and placed in the header, which has also been selected at random. The pushing of the tube its entire length through the tube holes in the header does not injure the bearing surfaces of the cone-shaped holes, as the tube rests on the small diamater of the hole, which, of course, is away from and has no relation to the bearing surface at the point of contact of the joints. The tubes are now on an inclination of one in ten inches in their relation to the vertical header. To complete the assembling of this part, which is now and will hereafter be termed an element, only the inner or circulating tubes are necessary.

The plug used on the outer end of the circulating tube (Fig. 10), and screwing into the large lantern on the end of the evaporating tube, is a drop forging. The machining of this plug consists in its being placed over a hexagon mandrel and threaded

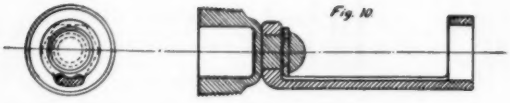
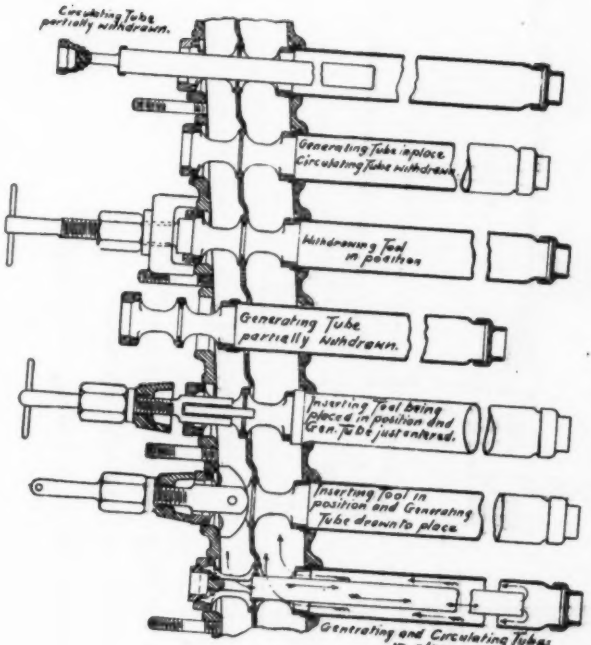


Fig. 10

with six double threads to the inch, the angle of which is the same as that in the lantern of the evaporating tube previously mentioned, the process of which has been described heretofore. The small lantern is also a drop forging, and does not call for any necessary mention as regards the machining.

The circulating tube is of Swedish steel, varying from No. 18 to No. 24 B.W.G. in thickness. This tube is made of two strips of metal, thus giving two seams, which afford additional strength and rigidity.

Fig. 8 shows how these parts are assembled. This circulating tube is now taken to the testing blocks and entered into its place in the evaporating tube, the threads of the plug being covered with the non-corrosive mixture before going into the large lantern. When the circulating tube is in place the hole in the center of the large lantern is closed, thus forming a tight diaphragm extend-

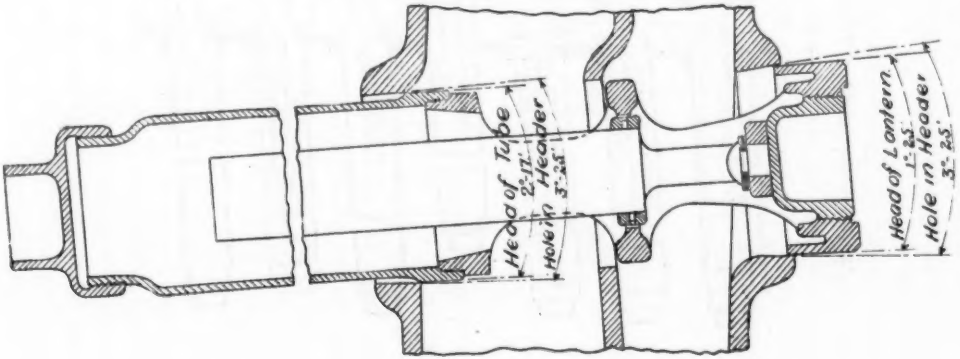

Circulating Tube partially withdrawn.
Generating Tube in place. Circulating Tube withdrawn.
Withdrawing Tool in position
Generating Tube partially withdrawn.
Inserting Tool being placed in position and Gen. Tube just entered.
Inserting Tool in position and Generating Tube drawn to place.
Centrating and Circulating Tubes in place.

—Fig. 8—

Method of inserting and removing the Tubes.

Section Through Tube, Lantern and Header
Showing Respective Positions when
Lantern Cone Begins to Bear.

Fig 9.



XU

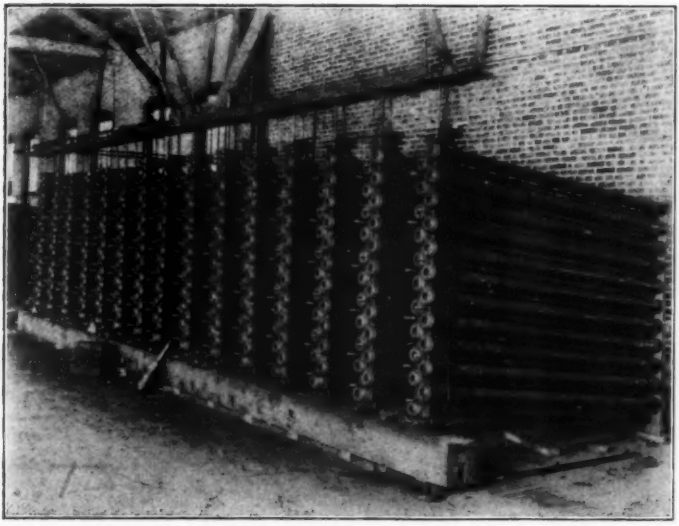


FIG. 11.

ing the full length of the header. We now have the element complete and ready for testing.

Fig. 11 shows the elements set up and ready for the test.

This simply consists in plugging the bottom holes in the header (for blow-off connections) and filling the header with water through a top flange which has been fitted tightly to place in the large top cone hole, this flange having connections for the entrance of the water and also for the escape of the air. Pressure is then applied to 500 pounds to the square inch, under which pressure all joints are absolutely tight. It will be noticed from Fig. 11, that the tube dogs are not in place, for the reason that it is not necessary in testing the boiler under hydrostatic pressure. The tubes are not blown out, as the difference of areas of the front and rear ends is so slight that whatever additional force is exerted, tending to blow the tubes out, is overcome by the slight adhesion of the cone joints. As a matter of fact, frequently in demonstrating matters pertaining to the fitting up of an element a pressure of over 900 pounds is applied without putting on the tube dogs, and no tubes are forced out.

It may be remarked that while successive removals and insertions of the tube in the header holes does necessitate the tubes being pushed in a little farther each time, the amount is infinitesimal. To those who question this statement the writer may explain that he was offered the opportunity of inspecting the Niclausse boilers at the Eiffel Tower, which at the time of his visit had been in use seven years, and not enough damage had been done during this time to necessitate any more than the ordinary repairs required to maintain the boiler in service, notwithstanding the frequent removal of tubes.

Assuming that fifteen elements, which is usually the number necessary for one boiler, are now fitted up and satisfactorily tested, they are all ready to be placed in the casings.

The casing (Fig. 12) presents a design combining strength, rigidity and a minimum weight, the especial feature of which is the lining of the casings with fire brick to the height of what may be designated the fire line, above which the casings are double-paneled, the spaces being filled in with a non-conducting ma-

terial consisting of 85 per cent. pure carbonate of magnesia and 15 per cent. asbestos fiber. In addition to this, slabs of highly refractory material, pressed into squares, are bolted to place on the inside of the side panels above the brickwork, experience proving that this method of insulation permits very little radiation of heat into the fire rooms and costs little to maintain in good order, while it fully protects the plates of the casing from burning or warping.

The fire and ash-pit doors are so arranged on trunnions as to open inward to an elevated position by a lever with adjustable counterbalance weights, the intention being that should a tube rupture or burst while the boiler is in service the doors would be closed by escaping water and steam, thus affording protection to men in the fire room.

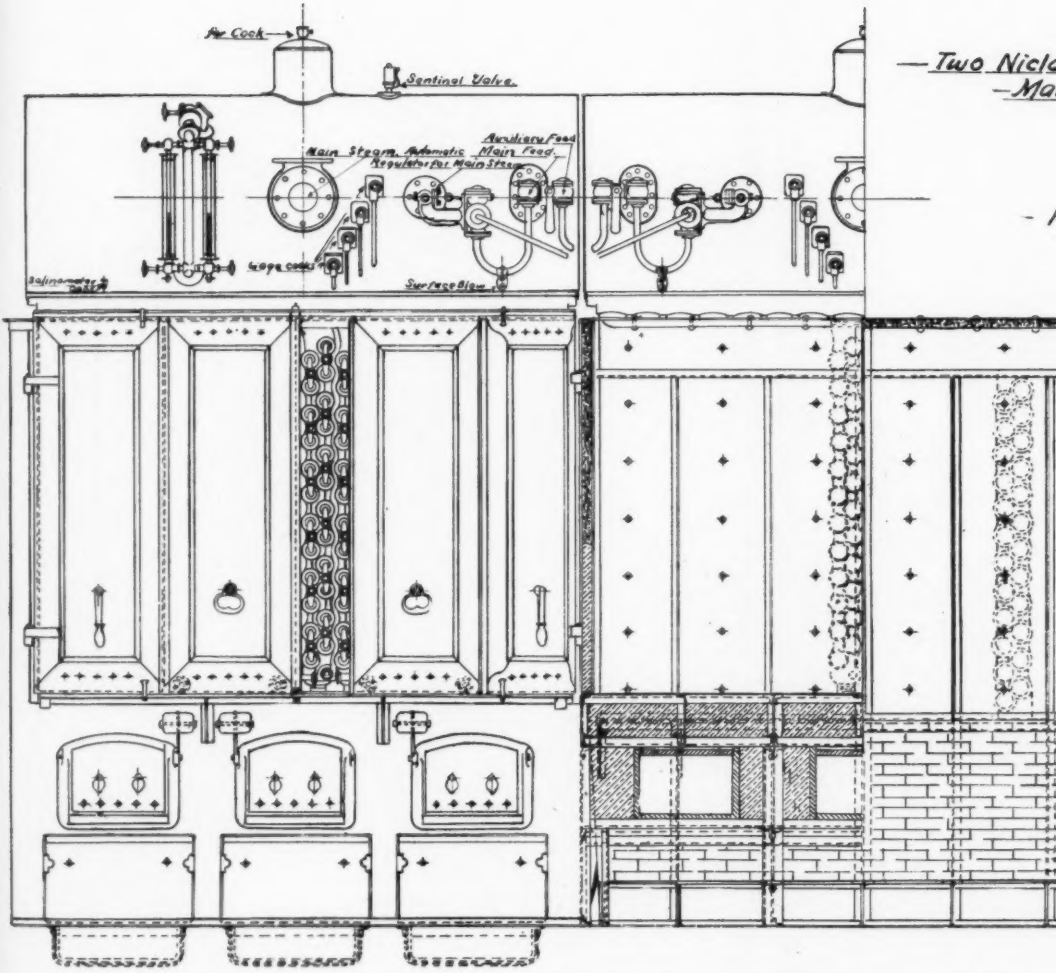
The neck or furnace throat is in four pieces of cast iron, consisting of a dead plate, two side or cheek plates and a crown plate, so grooved or dovetailed as to easily allow their removal when distorted or burned away, and their replacing by new plates. The connection doors are a series of double panels, each panel being of a width practically covering two header fronts, thus affording facilities for the easy removal of a header, or, if desirable, a complete element (header and tubes combined). The taking down of two or three of these panels also permits the removal of tubes for any purpose, or, if the boiler is in service, the blowing off by steam jet of soot from the tubes. All panels remaining in place may be moved from side to side, as they are interchangeable. This presents a decided advantage in the ease with which repairs may be made, tubes cleaned or removed, and all other work performed, that may be required by a boiler in service, from the front of the boiler, by the actual removal of only one or two doors.

Assuming that the casing is completed, the brickwork built in and the side panels filled with insulating material, the elements may be placed in position in their entirety, (Fig. 13,) or the headers put in separately and the elements erected by putting in the tubes singly.

When putting the tubes in the headers by this latter process a

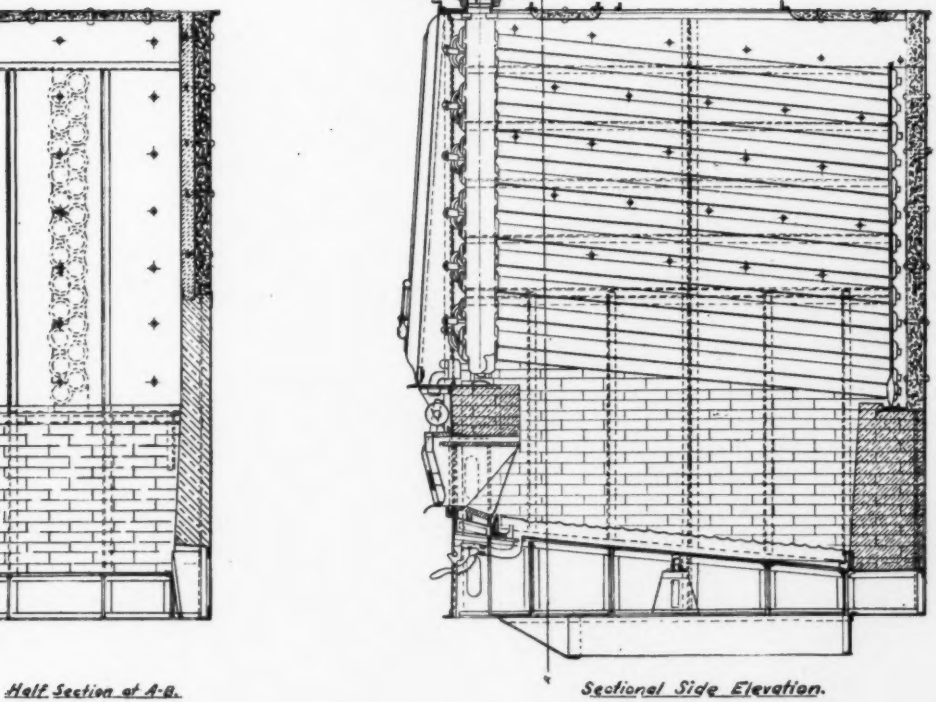
WAY

XU


Air Cock
Sentinel Valve
Two Nicke
Ma
Main Steam
Automatic Regulator for Main Steam
Auxiliary Feed
Main Feed
Surface Blow
Front Elevation.
Half Section with front plates removed.
Half Section

Two Niclausse Boilers in Battery—
—Marine Installation.—

- Fig. 12.-



Half Section at A-B.

Sectional Side Elevation.

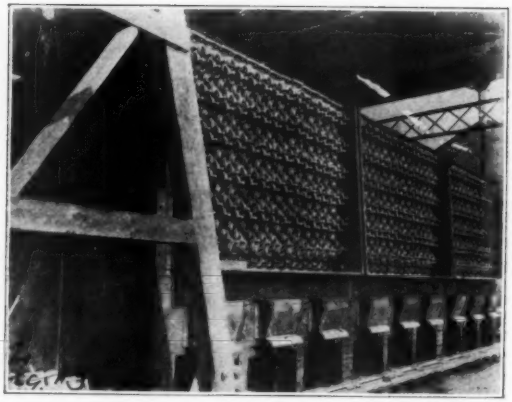


FIG. 13.

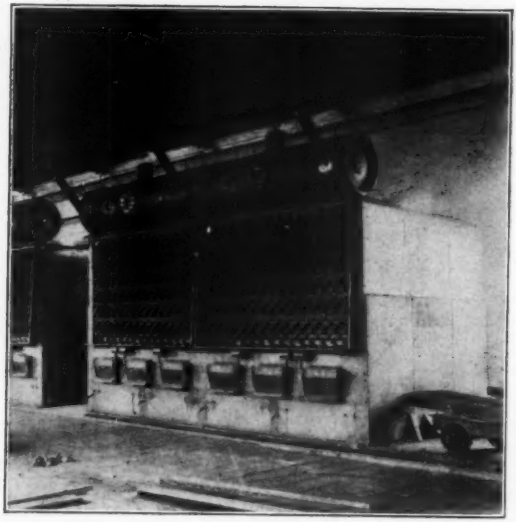


FIG. 14.

long stick is inserted in the tube, with the end projecting far enough to afford good leverage, so as to guide the rear tube end into its resting hole in the cast-iron supporting panel, which has already been bolted to place in the rear of the casing.

The necessary number of elements now being in place, the next step is the connection of the drum to the elements (Fig. 14) by bolting it to the top of the headers.

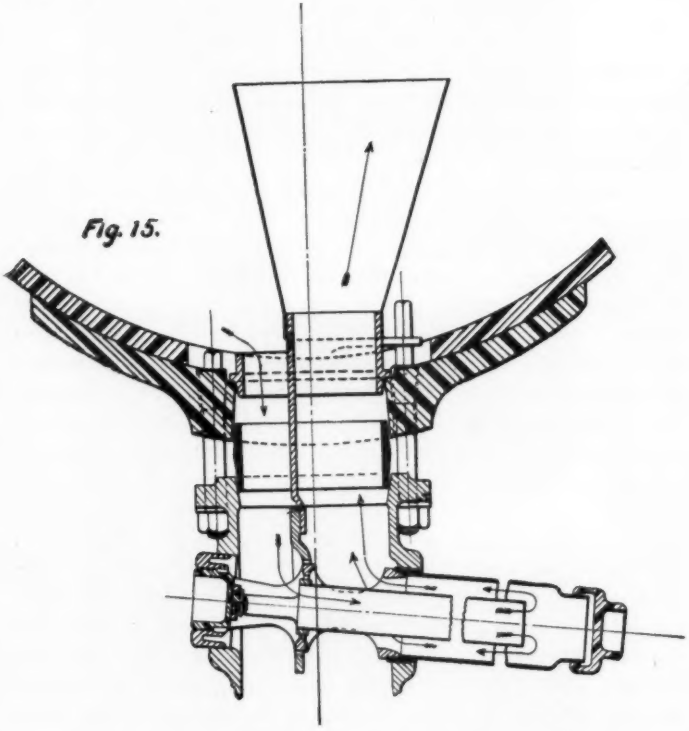
DRUMS.

In the construction of the drum the ordinary boiler-shop practices are followed, requiring no special mention other than that, as the drum is to be subjected to an unusually high pressure, all work is performed with care and thoroughness. There is, however, riveted to the bottom of the drum a heavy plate, which will hereafter be termed "header plate." This is usually 2⅜ inches in thickness, which is necessary to give strength through the section of the large cone holes that are drilled and reamed in it to an angle of 10 degrees. These cone holes, with the aid of cone nipples, form a connection to the elements. The plate is also drilled and reamed for the cone-bolt holes, four of which surround each large cone hole. Fig. 15 gives a comprehensive explanation of this header plate. This plate is planed on the sides and ends to reduce weight, and also to relieve the heavy, awkward appearance the plate would have if riveted to the drum in its full original thickness. All faying surfaces of the drum, after burrs, due to drilling through the solid plates, have been removed from rivet holes, are washed with a strong soda solution to remove oil, dirt, etc. After the drum is gotten ready for riveting throughout, all rivet holes are slightly rounded on the edges, which has the effect of forming a fillet under the rivet heads after they are driven. This is a good practice, and very materially assists in making tight work. The flanges of both heads in the drum looking outward permits both to be machine riveted.

The steam, feed and auxiliary feed pads (forged steel) are next fitted and riveted to place on the front of the drums, care being taken to have them at right angles with the axis of the large

cone hole in the header plate on the bottom of the drum. All the work of riveting now being accomplished, the drum is caulked inside and out by concave caulking tools. It is then tested to a pressure of 400 pounds to the square inch. This being satisfactory to the inspectors, it is now ready for connection to the elements. To form this junction between drum and headers of the elements a light double-cone nipple is used (see Fig. 15).

Fig. 15.



This also shows the cone-headed bolt used in bolting the drum to the header and drawing the cone-connecting nipple tightly to place. In making this connection the nipples are

placed in the large cone-header holes at the top of the headers, which it is assumed are on a perfect alignment and spaced the proper distance apart from center to center. The drum is then lowered onto the nipples, care being taken not to dislodge these nipples, as they must be drawn squarely into place. All the bolts are now put in from the inside of the drum down through the holes in the header plate and the nuts tightened up uniformly under the flange on the top of the headers. The principle which permits the cone and all the bolts to be tight is the same as that involved in making the tube joints tight in the headers, viz: the difference in the angles. The top cone hole at the top of the header and the cone hole in the header plate have each an angle of 10 degrees, while the double cone fitting into both these holes has a 5-degree 44-minute angle. The angle in the cone-bolt hole in the header plate is of 12 degrees 11 minutes, while the angle of the cone-headed bolt fitting into it is 10 degrees 48 minutes. It will thus be seen that the connecting cone and the cone on the bolt head make point contacts in their respective holes.

To complete the fitting up of the boiler in its entirety there remains only to connect the bottom of the headers with the line of piping termed the "blow-off connection."

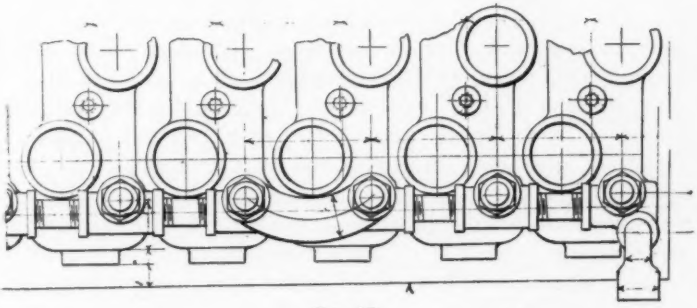


FIG. 16.

The blow-off connections (see Fig. 16) are a series of extra heavy malleable-iron fittings, consisting of pipe, nipples, and

double cone nipples, the joints of which are made tight by the same principle as that used in connecting the header-cone nipples to drum; all the parts being held together by long, cone-headed bolts, which enter the cone-bolt hole in the rear of the header, and extend through the header and cone nipple and its connecting link. The nut is then put on and the different members pulled tightly to position. This bolt is covered by a cap nut, faced off on its bearing surface to make a tight joint when in place.

The boiler is now ready for final pressure. It must be remembered that up to this time the drum and elements have been subjected to pressure singly, but the boiler in its entirety now undergoes a hydrostatic pressure of 400 pounds to the square inch. The drums and elements having already been found tight under pressure, care need only be taken in witnessing this final pressure to note if all cone connections and bolts are tight.

Where the boilers are set in battery, the two or more boilers are invariably fitted up together so that the drums may be perfectly aligned, to obviate difficulty that may be experienced on ship-board in making the different steam connections and running pipe systems from drum to drum. The boiler proving satisfactory to the inspectors, it is dismantled and prepared for shipment, all machined surfaces being carefully protected by the same non-corrosive mixture mentioned heretofore. The casings are taken down in sections large enough to permit of their going through the hatchways of the ship for which they are intended, so as to lessen work when they are erected in place. The drum, after being dismantled, has what are termed the "internal fittings" put in. These consist of a series of malleable-iron current separators, to which is riveted a funnel extending into the drum. (See Fig. 15, and sectional view of drum, Fig. 12.)

These separators fit down through the nipples connecting the header until they form a junction with the diaphragm in the header, the purpose of which is to establish an unrestricted flow of the currents of water and steam; in other words, to prevent the retarding of the down-flow of water on the forward side of

the diaphragm in the header by the rising flow of water and steam in the rear, as shown in Fig. 15.

There is also fitted in the drum a light sheet-steel box into which the feed water is discharged. To this box is connected a trough extending lengthwise of the drum, fitted with a series of baffle plates for the purpose of causing precipitation of foreign matter contained in the water, as well as to increase the temperature before the water is discharged into the boiler proper.

It is thus shown that the boiler is simply made, and not the intricate structure a casual observation would seem to indicate. An old-time boiler maker, when asked his views regarding it, in a contemptuous tone replied, "It ain't a boiler-shop boiler; it's a machine-shop contraption." He was right. It represents a step in progressive conception of steam generators, and therein lies a point in its favor; for while the warship in service may be equipped with one or two boiler makers who are by training able to cut out plates, drive rivets, caulk seams, etc., of the old-type boiler, the entire engine-room force, from the chief engineer down through the line of machinists to the oilers, are able to fit up any or all of the parts of the Niclausse boiler. By this the elements are particularly referred to, the tubes of which are the only parts subjected to the action of the fire (not considering the rear part of the header). Every ship, it is believed, should carry a limited number of spare tubes, lanterns, cone-header bolts, cone nipples, header studs and tube dogs; all of which are small parts and of little weight. However, should a ship fitted with Niclausse boilers be without these and require something, the necessary part could be "borrowed" from any ship in the fleet which also had Niclausse boilers, no matter of what type, excepting the headers, which would prove the only part different in the boilers, these being of different heights.

But the engineer will ask, "Assuming we are without an accompanying ship?"

The writer admits that being able to borrow parts is an advantange, but does not answer his query.

But what is liable to happen?

Assuming no spare parts are on board, a leaking cone connect-

ing the drum to header could be overcome by expanding. The breaking of a header would not put the boiler out of service longer than was necessary to remove the entire element and plug the cone hole in the header plate by gum washers backed with sheet iron, held tightly in place by the four bolts formerly passing through the flange of the broken header. To overcome the break in the blow-off connections it is only necessary to use a longer nipple than that which is now used in connecting the headers, which, being ordinary piping, can be easily supplied.

Should a tube rupture, it may be cut off close to the header, leaving the end of sufficient length to heat and smash together, bending the end back on itself if needed, and replacing this dummy tube and lantern in the header. It is reasonable to assume that ordinary tubes may be gotten in almost any port. The necessary machining of the threads required on the tube would be a simple matter. The material or stock to form the cone for the tube bearing could be obtained by welding a ring on the end of the tube. These matters would, no doubt, be equally as well, if not better, met by the engineer confronted with the necessity of making the repairs, who would have a better knowledge of the conditions and circumstances arising on shipboard, but the writer merely mentions these matters to show the possibility of their accomplishment.

The machine shop of the ship should be equipped with a lathe long enough to swing a tube between centers; and among the small tools, reamers for all cone holes that are in the boiler, also suitable taps. The writer considers it essential that a full set of gages for all taper joints, cone nipples, connecting holes, etc., such as are used by the workmen in the construction of the boiler be supplied to the ship; also two friction clamps (simple semi-circular parts, with draw bolts, capable of being fastened to stanchions or other convenient place), for each fire room, for the purpose of clamping a tube, to remove lantern or back cap.

The management of the boilers while in service requires no special instructions other than to emphasize the fact that all the joints are so easily made tight that it is possible for workmen in screwing up the nuts and forcing in the tubes to go beyond the

necessary limit. It has been demonstrated that in fitting the tubes in the headers a wrench for the inserting tool should not exceed 24 inches in length, and a pressure on the end of it of 60 pounds is sufficient to make the joint tight. To force the tube beyond this would not distort nor distress it, but tend to make more than a point bearing, which is simply unnecessary. The absolute interchangeability of all parts permits the tubes to be piled together in some out-of-the-way place while overhauling the boilers.

In conclusion, I would add that the boilers for the new cruisers recently contracted for are to have pressed-steel headers, which are preferable in the marine type to the malleable-iron headers heretofore used, but it may be said that in the ten years' use of Niclausse boilers in many of the ships in the navies of France, Italy, Germany and Russia, not a single accident can be attributed to this latter header, its very form and construction obviating many of the defects attributable to cast material. The malleable-iron lantern will also be replaced by a construction embodying tube and lantern in one piece, as shown in Fig. 17.

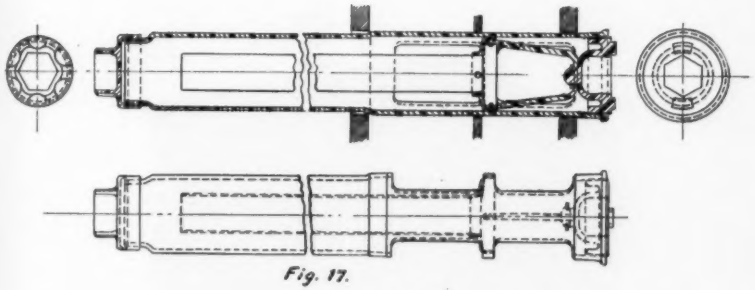


Fig. 17.

Improvements have been made in the internal fittings of the drum, with a view of simplifying it. It will also be seen from Fig. 12, that the front-connection panel doors are to be replaced by swinging doors at each side of the boiler, and two doors in the middle that move on rollers.

Figs. 18 and 19 illustrate the neat, compact and presentable

appearance of the Niclausse boilers now being installed in the United States monitor *Nevada*, which ship will have four boilers of the combination-header type. This for the reason that very little head room in the fire room is afforded for water-tube boilers, the height of these boilers from the foundation to the top of the steam dome being 10 feet 10¼ inches, the combined boilers giving an aggregate of 2,400 I.H.P. under a working pressure of 250 pounds to the square inch.

NOTE.—The writer begs to return thanks to The Stirling Company, of Barberton, Ohio, for courtesies extended in obtaining the necessary sketches and photographs; also to Lieutenant Commander W. C. Eaton, U. S. N., for information regarding ship practices.

FIG. 18.

FIG. 19.

TRIPLE-SCREW SHIPS.

By F. B., "Marine Rundschau," March, 1901.

[Translated for the JOURNAL by MR. A. H. RAYNAL, Associate.]

It has recently been reported from the United States that the new armored cruisers that are just about to be laid down are to have two screws, and not three like their predecessors. This report is somewhat surprising, for it is opposed to the views of Admiral Melville, the Engineer-in-Chief of the U. S. Navy, who, only last year, in a very elaborate paper on "The Logical Arrangement of the Motive Power of Warships," expressed himself in favor of the three-screw system for large warships. He claims to have given the subject of triple screws much study, and believes that their employment on warships is entirely logical. In support of this, he explains fully their advantages and disadvantages, and concludes that the former outweigh the latter. Finally, he favors the arrangement of the three engines in such a manner that the central engine shall develop one-half and the wing engines each one-quarter of the total power.

Though I do not quite agree with this eminent authority as to this latter distribution, I nevertheless am of the opinion that, *for the German navy, the triple-screw system is the only correct one for battleships and large cruisers.* While Admiral Melville, from his position, considers the advantages of this system especially from an engineering point of view, I wish to emphasize the nautical side of the question. In order to get a comprehensive idea of this question, the engineering reasons will be briefly mentioned, as this seems to be necessary for a complete review.

Ships with more than two screws have been in existence for a long time. In Chapter IX of Professor Busley's well-known book, "The New Express Steamers of the Merchant Marine and the Navy," all cases are mentioned in which three screws

had been employed up to August, 1892. Some of the reasons that led to the use of the triple-screw systems therein mentioned will be referred to later; for the present it will suffice to state the principal reason that led to the adoption of three engines for the *Kaiserin Augusta.* It was "the possibility of reducing the engine power without involving too great a loss in efficiency, by the adoption of several small engines." This seemed to be specially necessary for steamers that do not often use their full power, but have frequently to go at reduced power and varying speeds. It was thought that, when cruising at speeds of ten to twelve knots, the triple-screw cruisers would have their wing engines disconnected, and the center engine only in operation. When maneuvering, and when greater speed was required, the reverse arrangement was intended, and only in special cases were all three screws to be used.

The expectations that were based on this method of operation have not been realized, as the trials of the United States triple-screw cruisers *Columbia* and *Minneapolis*, and our *Kaiserin Augusta* have shown. Fuller particulars were given by Professor Busley in a paper on "Our Navy," published in number 32 of the "Zeitschrift des Vereines Deutscher Ingenieure" of August 8, 1896. With the exception of a single condition, which, however, has nothing to do with the general efficiency, the use of the central screw alone is scarcely mentioned nowadays. That the triple-screw ships are especially economical for longer distances, at cruising speeds, when they use the wing engines only, is, however, unquestioned. For ships operating in squadron, we must consider almost exclusively the use of all three engines. In this case, it has been found that, at low speeds, the *coal consumption of triple-screw ships is somewhat greater* than that of twin-screw ships, while at higher speeds it is the same. It is, therefore, necessary to try to make the triple-screw system more efficient for the more frequently occurring condition of cruising speed.

Another objection to the installation of three engines is that a somewhat *lower speed is obtained* than with two engines for the same total power expended. This, however, had been clearly

foreseen, and it was not expected, as has sometimes been stated, that higher speed would be obtained with three screws.

In addition to the above two disadvantages there is another of great military importance, and that is that the entire *installation is more complex and more difficult of supervision.* The machinery installations of modern warships are of such complexity that an increase in this direction must always be regarded as a great disadvantage. It is evident that the entire pipe system for three engines must be much more complicated, the signaling apparatus more intricate, and the number of auxiliary engines more numerous. In regard to the latter condition, however, a rather favorable circumstance should be mentioned—that some of them can be quite comfortably installed in the after engine room, whereas, with two large engines side by side, room must be found in other parts of the ship.

A greater objection than all three, however, is that the supervision of all the machinery is much more difficult for the engineer in charge with three engines than with two. This also depends largely upon the space that can be given up to the various engines, and may accordingly be more or less annoying. For instance, in the battleships of the *Kaiser* class, these conditions can not be regarded as anything but very unfavorable.

This complexity of the triple-screw system is such a great objection that it should not be increased under any circumstances; but this would happen if the proposition of Admiral Melville, to put in an unequal distribution of power for three screws, were followed. Further comment on this is probably unnecessary.

A further disadvantage in the use of three screws is that the whole engine space *requires more room lengthwise*, say from two to three frames. In consequence of this, the heavy after turret must be placed still further aft, which involes a larger amount of broadside armor for that part of the ship which is between the two large turrets. In the new ships of nearly all nations this armor reaches part to the upper deck and part to the gun deck. The increase in weight is made up by the smaller weight

of the triple-engine machinery, as previously mentioned; for the latter is always lighter than the installation of two engines.

Though of less importance, it may be mentioned that three engines are *more expensive to keep up* than two engines.

I do not attach much importance to the further objection to three engines, that a *larger personnel* is required for attendance. Assuming for each watch one engineer and two assistants, an additional complement of three officers and six petty officers will be required for the three engines. With an engine-room complement of from 180 to 200 all told, the increase by this number does not amount to anything, but rather affects the quality of the complement. With the many additional installations of machinery on the modern warship, such additions to the personnel may well be utilized outside the main engines.

A more serious objection may be urged against three screws on *constructive* grounds, due to the difficulty in securing a good construction of the stern. Twin screws are placed at either side of the stern post, from which the rudder can be easily and securely suspended. If a third screw is added, it must be arranged like the screw of a single-screw ship. Its shaft must pass through the stern post, and the screw itself must be placed immediately aft of the stern post, while a special post must be arranged for the rudder aft of the screw. For this post, or for the rudder, a special support is necessary, and it must be of strong, and, therefore, of heavy construction.

As is well known, such a support is not a very desirable addition, especially when it forms the lowest part of the ship. It has, therefore, been arranged in the more recent triple-screw ships to dispense with this, and to merely suspend the rudder from a post that is specially constructed for the purpose. To better protect it from injury, it can be built so that its lowest point will be above the bottom of the ship's hull proper. I do not believe that the effect of the rudder is thereby diminished. If it were, the rudder might be made correspondingly longer; and, further, it will be shown that the excellent efficiency of the rudder with the triple-screw ship depends entirely upon the action of the center screw.

It is not admitted that there is great difficulty in obtaining a good and secure suspension of a rudder that is supported only from above. The stern frame, as is well known, is supported by the central portion of the ship, and is, therefore, greatly exposed to the vibrations of the engines. The difficulties are not insurmountable, as I have been assured by naval constructors. As a proof of this, the alterations to the rudder of the *Victoria Luise* may be mentioned. She lost her rudder support, and it was not replaced; the post, and the other parts from which the rudder was suspended, were merely strengthened, and, on the trials following this alteration, the arrangement of the rudder was found to be perfectly satisfactory.

The difficulty in well and securely arranging the rudder, when three screws are used, cannot, therefore, be regarded as of such great importance as to justify serious objections to the triple-screw system.

To offset the above disadvantages of the triple-screw system, the following *important advantages* may be mentioned:

First of all, it will be apparent that, with three engines at disposal, the *assurance of working the entire machinery* plant is greater than with only two engines. This advantage may be of special significance in battle. If from any cause, either internal or external, an engine is disabled, there still remains two-thirds of the entire power, while in case of the disablement of one engine where there are but two screws, one-half of the entire engine power is lost. This will be referred to later.

Many advantages result from the smaller dimensions of the machinery by reason of the division of the power into three parts. As an illustration, let us assume a special case. Let the question be whether a battleship of about 12,000 tons, with engines of 15,000 horsepower, shall have two or three screws. These are about the proportions that obtain with our recent battleships. In one case there are required two engines of 7,500 horsepower each, and in the other three of 5,000 horsepower each.

It is evident that the three *smaller engines can be built simpler and lighter* than the two larger ones; and it may also be men-

tioned that the *smaller engines are cheaper.* All their details of wrought or cast material will be smaller, can be manufactured more easily, and are more likely to be free from defects. While the consequences from a failure of one engine are of less importance, it follows also that such failures are less likely when smaller engines are used. With the steam pressure now used, it is possible to build an engine of 5,000 horsepower with three cylinders, while one of 7,500 would necessitate four cylinders. While I do not wish to assert that four-cylinder engines will never satisfy the high requirements demanded of them from a military point of view, nor have the handling qualities required in the engines of a battleship, it is certainly true that three-cylinder engines satisfy the requirements much better in this regard. The advantage of the triple-screw system in this respect is, therefore, not to be underestimated.

The fact that smaller engines are *more easily managed and supervised* requires no argument.

From a purely engineering standpoint there are further advantages of smaller engines, for which I would refer to Admiral Melville's paper, and now proceed to a consideration of the constructive advantages.

To obtain high speeds it has been found necessary to design ships with very fine lines aft, because the water displaced by the vessel will thus find easy egress, and have better access to the screws, thus securing better efficiency. But in a vessel that is fine aft, it is much *easier to arrange for three smaller engines,* of which the central one is aft of the others, than for two large ones side by side. The latter have to be placed much farther forward, and while this, as already mentioned, has some advantages, it is, on the other hand, very unfavorable for the propeller shafts. These have to be much longer, and will, therefore, be much more subject to torsion and to bending strains when the vessel is pitching.

With engines in a fine afterbody, the *foundations are very much lighter,* because the frames are placed much nearer together and can, therefore, support them to better advantage.

A further *advantage of smaller engines is their lesser height.*

This affects, on the one hand, the draught of the vessel, and on the other, the armor for the engines. The *lesser draught* that can be obtained with three smaller engines was the first reason for installing them. This reason still exists, and is of special importance for navies that have to consider shallow waters, which is especially the case with the Navy of the United States. Besides, it must not be forgotten that each inch of additional draught calls for greater engine power to obtain a given speed.

As regards armor protection, the situation is best illustrated by a comparison between our *Hertha* class and the English cruisers of the *Arrogant* class. These two types are of approximately the same size, and have equal engine power. While the three engines of our ships have been placed below the uninterrupted protective deck, the engines of the English ships project above it, and had to be protected by a special armor shield. Therefore, the protective armor for an installation of three engines is *simpler, lighter and cheaper* than it is for one of two engines. Whether in this special case it would have been possible to instal below the protective deck two engines of 7,500 horsepower each, on the comparatively light draught that is required for our navy, I very much doubt.

The *smaller engine rooms* required by the smaller engines are a further advantage. The *safety of the ship* is thereby considerably increased when leakage occurs in the vicinity of the engine rooms. To this must be added the additional security from external injury which is given to the central engine by reason of its position. This also applies specially to the central screw, and also to the *wing screws* in a triple-screw ship, which are much *better protected* than in twin-screw ships. In consequence of their smaller diameter, they can be so arranged in a battleship as to be entirely covered by the hull. It matters not what opinions are held on the subject of ramming, but it will happen in most cases that the ramming and the rammed vessel will pass each other broadside to. Everything that projects beyond the hull will simply be sheared off, and in twin-screw ships the large screws will be the first thing to go. Even in times of peace these large screws are very much in the way when going into

dock, passing through locks, and going alongside a wharf, and they require special attention when maneuvering. And what trouble and annoyance screw protectors (propeller booms) are!

We have now reached the *nautical* aspect of the question. A great many circumstances might arise under war conditions which would emphasize the advantage of the better protection of the machinery of a triple-screw ship. But, as such considerations are more or less theoretical, each one may indulge in them according to that part of the subject in which he is most interested. For me it is more important at present to point out the *tactical advantage* of the triple-screw system based on practical experience that has so far been gained on the *Kaiser Friedrich III*, the first triple-screw battleship that has been assigned to service with the home squadron.

For a clearer understanding of the subject of "ability to maneuver," the following particulars of this ship are given:

Kaiser Friedrich III has a ratio of length to breadth of 5.6 to 1 (*Brandenburg* has 5.4, *Sachsen* 5.4 to 1). The after body of the ship under water is rather fine. The wing screws are covered by the hull. The rudder is half balanced, similar to those of the *Brandenburg* class, and rests upon a support below the central screw. The steering engine is worked with surprising ease through operating gear that is supported in ball bearings along its entire length. The engines are triple-expansion, with three cylinders, the wing screws turning outward and the center one left handed. The convergence of the shafts of the former is such that their axes prolonged would meet within the ship about 130 feet from the bow.

	Friedrich III.	*Brandenburg.*	*Sachsen.*	*Baden.*
Number of screws	3	2	2	2
Displacement	11,130	10,033	7,400	7,400
I.H.P.	13,000	9,000	9,600	6,200
Speed	18	16	14	17.3
Bunker capacity	650	800	700	700

This ship cruised with the *Bradenburg* and the *Sachsen*, and excellent and extensive opportunity was given for comparing

them. Besides, there were on board of her two experienced officers who had commanded vessels of the *Brandenburg* class, and watch officers who had served as such on the *Baden*.

The following account of the evolutions are based upon the unanimous statements of these officers.

Primarily the objection has been made to triple-screw ships that, were they introduced, it would be necessary to give our officers special training in handling them if they had only been accustomed to handling twin-screw ships. This objection falls to the ground when we consider that we now have *ten battleships and nine large cruisers with three screws*, either completed or in process of construction, and that, in the near future, as far as can be seen, our first squadron will consist entirely of ships of this type. It is, however, proper to state that we need information on the management of three screws, and particularly so when maneuvering in squadron. This information has already been gained to a great extent on the *Kaiser Friedrich III*, and will be completed in a short time. There are only a few more points that have to be noted. It is certain that the training of the officers on this ship was accomplished without difficulty, and those who have any talent at all for maneuvering will very soon become accustomed to three screws.

The good nautical qualities of the triple-screw system consists mainly in the excellent steering of the ship. With a judicious use of the helm, the ship is very steady, and the keeping of a given course presents no difficulties; and it must be added that new helmsmen learn to steer with exceptional ease and rapidity. This is something that speaks well for the triple-screw system, for it must be remembered that constant changes take place among these men, and that in case of mobilization we may have to put entirely new ships in commission. The merit of this good steering quality lies solely in the third screw, because, situated as it is just ahead of the rudder, it projects the water right on to it. Since twin-screw ships do not act so favorably in this respect, it may be stated as a fact that a great *advantage of the triple-screw system consists in ability to steer well, and that with it steering is easily learned.*

It is well known that single-screw ships steer well when their engines are going ahead, and this is probably responsible for the opinion at first expressed, that a triple-screw ship in her entire behavior approximates the action of a single-screw ship: That like it, in all maneuvers, it is dependent upon its rudder alone. To this we offer decided objection! The *Kaiser Friedrich III* was always handled as a twin-screw ship, the center screw always turning ahead, and thus exerting a favorable influence upon maneuvering, by its action upon the rudder. If, when lifting anchor, or casting off from a buoy the ships had to be turned, say 16 points, to enter upon the course ordered, it was always found that the *Kaiser Friedrich III* performed the evolution quicker and in less space than the *Brandenburg* class, and at least as well as the *Sachsen* class.

On the other hand, it is true that the motion of the wing screws does not have such an immediate effect upon the turning of the ship as in a twin-screw ship. If it becomes necessary to make a sharp turn at the commencement of a run of greater or less duration, the stopping, or even the backing of the center screw, has no very noticeable effect upon the turning movement. On account of the otherwise excellent turning qualities of the three-screw ship, which answers the helm almost immediately, this circumstance has never appeared to cause annoyance when in squadron.

Furthermore, the following evolution was executed: The ship lay at the south wharf of the fitting-out basin at Kiel dockyard, west of the passage to the building basin, heading east, and left the wharf without using the lines that were got out. It is true there was no wind, but I doubt that a single-screw ship of the same size could have performed this evolution under the same conditions. It should also be noted that the fitting-out basin was not empty, but that there were two or three large vessels lying close to each other on its north and east sides.

On the other hand, in backing, steering by means of the screws, especially under unfavorable conditions of wind, is exceedingly difficult. But in spite of this, it may be said that the *Kaiser Friedrich III* has left the wharf at Kiel *backing* under the most

trying circumstances, and that they always succeeded in taking her to the desired place.

However, as regards the *lesser effect of the wing screws*, it must be stated emphatically that this is only a *consequence of the convergence of the wing-screw shafts*, which approach so closely forward; and, therefore, it must not be assumed to be an objection to the triple-screw system in general. This convergence of the wing-screw shafts is due to the comparatively small beam of this ship, which necessitated this construction. Where this is not required, as will be the case in our new battleships, and when the wing shafts are parallel to the plane of the keel, the effect of their screws would be the same as in a twin-screw ship. With the increased engine power, I would suppose it more probable that, with three screws, the wing screws could be more easily arranged with parallel shafts than with the larger screws of only two engines. If this assumption is found to be correct, then the effect of the screws in the latter case would also be less. At any rate, as has been mentioned, the objection to their projection beyond the ship's side cannot be removed.

The conclusion to be drawn from this is that the *triple-screw ship with parallel shafts is superior to the twin-screw ship in ability to maneuver.*

I shall mention here one peculiarity of the *Kaiser Friedrich III*, which, I believe, at one time produced a rather unfavorable impression regarding her maneuvering qualities. When she is making a sharp turn, and it is desired to stop her forward motion, she continues to turn when all engines are stopped, even if the rudder be thrown hard over. And yet this faulty condition can be easily avoided. It is only necessary to bring the rudder into action by letting the center engine go ahead, and at the same time check the forward motion of the ship by backing the wing engines.

A similar case is the following buoy maneuver, which can be executed only with three screws. After all the engines have been going ahead at slow speed, the wing engines are stopped at a certain distance from the buoy, and when near the buoy are backed until the ship comes to a standstill; then all three engines are

stopped. The ship is kept under control by the center engine going ahead until the last moment, thus acting upon the rudder. This, as is well known, is not the case when this maneuver is attempted with a single or a twin-screw ship.

It only remains now to mention briefly the influence of casualties *in battle*, to either rudder or engine, in a triple-screw ship. In a twin-screw ship, if one engine is rendered inoperative, only one-half of the entire engine power remains for propulsion. The helm has to be put over from five to ten degrees towards the side of the injured engine in order to steer a straight course, by reason of which a part of the speed, even though a small one, is lost; but the ability to maneuver suffers to a great extent. The three-screw ship, however, loses only one-third of her engine power, with a corresponding reduction in speed, when one wing screw is put out of action.* The steering is hardly affected, because the central or steering screw remains intact.

If the rudder gets out of order in a twin-screw ship it is necessary to steer with the screws, by which more or less speed is sacrificed, according to the evolution. If, however, the triple-screw ship becomes rudderless, she can be steered with the wing screws; and even with the unfavorable arrangement of the wing shafts on the *Kaiser Friedrich III* this can be done without any special difficulty. But there the entire power of the center screw is available for the forward motion.

Therefore, in these battle casualties, three screws are more advantageous than two.

If I were to condense all that has been said before, I should come to the following conclusions: The three-screw system has weighty arguments in its favor from a mechanical standpoint, but there are also some against it that should not be underestimated. It appears to me that the advantages exceed the disadvantages, although I am fully aware that others hold a contrary

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* Prof. Busley says on this point: "Experience has taught that twin-screw ships obtain only two-thirds of their maximum speed where one disabled engine or screw is standing still, although the entire steam supply can be utilized for the engine that is in good condition. Should the triple-screw ship, however, lose a screw, it is possible to obtain nearly nine-tenths of her maximum speed with three screws."

opinion. However, from a nautical standpoint, the advantages are so great that I consider the use of three screws on large battleships absolutely correct. *And this point of view must be the controlling one* in the solution of the question. The majority of our technical officers would be of my opinion in this matter.

But if it be asked how the other great navies stand in regard to the use of three screws, it must be said:

1. The United States are again building only twin-screw ships; opinions there are, however, much divided.

2. Russia is still wavering; in her new large ships we find two as well as three screws.

3. In France, all new battleships and large cruisers are fitted with three engines.

4. The British Admiralty has vigorously opposed the triple-screw system, which is astonishing.

It would be manifestly wrong to form opinions against the triple-screw system from merely sentimental considerations. And yet there are officers who, without having had an opportunity of becoming familiar with three screws, and who, without being able to mention any special point against them, believe that the triple-screw system can not be good, because—the English have not yet adopted it. It is particularly to these of my comrades that I hope I have been able, in the preceding statements, to furnish an opportunity to become acquainted with the real arguments for and against triple-screw ships.

But to return to the English. It must be pointed out how inordinately conservative they are in holding on to old methods, and how they object to anything new in their navy. It was only after the French had built ironclads, and had successfully tried them, that the English decided to change their "wooden walls" to iron ones; and they were many years behind other navies in adopting breech-loading rifles.

Nevertheless, it should be stated that even in the English Navy voices have lately been raised for the introduction of the triple-screw system. I shall only mention the case in the number of the "Journal of the Royal United Service Institution" for July, 1900, in which Lieutenant Commander Villiers, in an

honorably-mentioned prize essay, advocates the use of three screws in the British Navy. He says: "*The reasons in their favor seem to outweigh those against them*," and lays special stress upon the reduction in draught and the correspondingly higher speed.

Admiral Melville also mentions in his paper the fact that no English warship has three screws, and seeks an explanation in the fact that English constructors do not have to deal with light draught to the same extent that the American constructors do.

But whatever reason may exist for the astonishing fact that the triple-screw system has not yet been introduced in the British Navy, there is a *strategical reason* for the use of three screws by us. It is this: A three-screw ship can pass through the Kaiser Wilhelm canal with great ease.*

It is true that our other ships have passed through it, but the demands upon their management were entirely different. Whoever, for instance, has passed through the canal, first in the *Baden* and shortly afterward in the *Kaiser Friedrich III*, must have been impressed with the immense advantage that the three-screw ship has over the two-screw one. On the *Baden* the best helmsmen were steering, and in spite of this the officer of the watch had repeatedly to help out with the engines in order to keep the ship on her course. He could not for a single moment withdraw his attention from the steering of the ship, which fact made it necessary for the officers to be relieved every two hours during the passage. The conditions on the *Brandenburg* class were similar, though somewhat better. It must be added that these ships, and it is probably the case with all twin-screw ships, cannot exceed a certain number of revolutions, determined by experience, otherwise they have a tendency to run away from their rudders and thus cause damage to the banks of the canal by the increased stern wave.

The passages through the canal with the *Kaiser Friedrich III* were entirely different. She was brought through the locks without any thought of damage to the wing screws. After leav-

* See the report of the trip of the *Fürst Bismarck* in the January number of the "Marine Rundschau," page 82. [Also JOURNAL, Vol. XIII, page 295.]

ing them, the wing engines were stopped and the center engine proceeded with just as many turns as were necessary for the prescribed speed through the canal. In this way this ship of 11,000 tons went through the canal as easily as a small boat. There was no intense attention by the officers of the watch, no anxious walking hither and thither of the navigator. The engine telegraphs were not touched; quiet and peace prevailed on the bridge. The speed was low for a vessel of such large displacement, and might have been increased with safety without lessening the good steering qualities of the ship, and without injury to the banks of the canal, for there was hardly any stern wave. It is to be hoped that trials of this nature will soon be made.

The Kaiser Wilhelm Canal was built primarily for strategical reasons, and, as far as can be seen, it will play a great role in any naval war with Germany. Is it not, then, self-evident that we should employ all aids that are given with the triple-screw system to make a quick passage, if necessary, without regard to the canal, and one that is safe under all circumstances?

If our new battleships had twin screws, it is more than probable that they could never pass through the canal or the locks without injury. And what would be the conditions if such ships had just been commissioned and were without an experienced crew?

If the advantages of the triple-screw system from a nautical standpoint have caused me previously to declare in favor of them for general use, it follows from a consideration of these last conditions that, for the *German Navy, it is absolutely necessary to fit all the large ships of the home fleet with three screws.*

A DESIGN FOR A FAST SCOUT.

By Rear Admiral C. C. P. Fitzgerald, R. N.

[Paper read before the Institution of Naval Architects.]

I beg to lay before the meeting a design for a scout of high speed and good seagoing qualities.

I am responsible for the general idea of the design, but, not being myself a ship designer, I have been obliged to ask for professional assistance, and Mr. Philip Watts, of Elswick, has most kindly taken all the trouble to work out the design for me, and to carry out my views, so far as that was possible on a given tonnage; though, of course, we naval officers always want more than we can get, and more than the laws of hydrostatics will admit of.

I have also gratefully to acknowledge the assistance of Admiral Sir John Hopkins, whose great experience and sound, practical views on all naval subjects are universally admitted.

The proposed vesssl is to be of 3,800 tons, 400 feet long between the perpendiculars, 44 feet beam, with a draught of 14 feet with her normal coal supply on board; there will be two screws, and the collective horsepower will be 16,000. The armament is to be six 4-inch guns and a dozen machine guns. There will be a protective deck 2 inches thick on the slope and 1 inch on the flat. There will be no double bottom through the boiler compartments, but there will be elsewhere. The 4-inch guns will be protected with 4-inch shields, except the foremost and after guns, which will be in 4-inch gun houses, and the conning tower will be of the same thickness. The speed is to be 25 knots, but the whole idea of the design has been not so much to procure a very high measured-mile speed for a few hours as to assure a good, continuous ocean speed, as long as the coal lasts, and this is to be 23 knots. The normal coal supply is 500 tons, but the

bunker capacity will be for 1,200 tons, though I need scarcely say that the vessel will not go 25 knots with her bunkers full.

The original idea was to have a smaller vessel with very quick-running engines; but, taking into consideration the liability of such engines to give trouble when run continuously at sea, it was decided to have less quick-running engines, and, consequently, a larger ship. The boilers will, of course, be tubulous—probably of the Yarrow type. The ventilation will be artificial, and there will be no cowls.

Turbine engines were contemplated; but, after full consideration, reciprocating engines have been decided upon.

It seems necessary that I should show cause for proposing a design for a ship of war of this tonnage, with such a very insignificant armament.

In the first place, then, I would beg to point out that she is not intended to be a "ship of war" in the ordinary sense of the words; that is to say, she is not intended to be a fighting ship, and thus the proposed armament must be regarded as altogether of a secondary, or rather of a tertiary, importance; the two first qualities aimed at being continuous high speed and good seagoing qualities in all weathers. It will, therefore, prevent confusion, if we call her a despatch vessel or a scout.

She may not make much show on paper, though that is a matter of small importance, if it can be shown that such a vessel, or, rather, a considerable number of such vessels, would be of the most vital importance to enable us to carry out our avowed strategy in the event of war with a maritime power; and notwithstanding that the want of such scouts may not become apparent until war is actually upon us, or, in other words, that there is no use for them in peace time. And in this connection I may remind you that, at the time of the Russo-Turkish war, in 1878–9, when our squadron passed through the Dardanelles, and it seemed probable that we should be involved in hostilities, the want of fast scouts became so urgent that the Government were obliged to buy up hastily a number of Liverpool tugs, as our own small craft of the day were so deficient in

speed and coal endurance that they were practically useless for the duties of scouts and despatch vessels, notwithstanding that they could sail.

It has often been suggested that we ought to keep ourselves ready for war at short notice, so as not to find ourselves in the position of having to extemporize any important class of vessels as auxiliaries after war is declared or becomes imminent; and, with regard to scouts, there do not appear to be any vessels in existence which would meet our requirements. The Transatlantic liners are too large. The Holyhead boats and the Channel Island packets are fast vessels and good sea boats, but their boilers and engines are unprotected, and their coal supply altogether insufficient to enable them to act as scouts; and our old friends, the Liverpool tugs, are scarcely up to present-day requirement with regard to speed.

It is generally understood that in the event of war with a maritime power, it would not be possible to institute a close blockade of the enemy's ports in the same way that we blockaded during former naval wars; but that it would, nevertheless, be absolutely necessary that we should be able to watch those ports in such a manner that the exit of hostile ships in any considerable numbers could not take place without the admirals in command of our battle squadrons being promptly informed of the fact. But, although this is the leading feature of our avowed strategy, it is difficult to see how it is to be performed, or what warships we have capable of doing it. To begin with our first-class cruisers: they are too valuable to be exposed to the great risk of watching off an enemy's port, which probably would contain numerous torpedo boats, and, perhaps, some submarines; secondly, there are not enough of them; and, thirdly, they would have quite enough to do in protecting our trade routes from the depredations of hostile cruisers, which are certain to escape, in spite of the closest watching. Next take our second and third-class cruisers, with nominal speeds of about 19 and 19½ knots; some of the smaller ones (the *P* class), having a speed of 20 knots in smooth water; it does not seem likely that they will be per-

mitted by an enterprizing enemy to keep watch off a port which will probably contain several powerful armored cruisers of large size, and with nominal speed of 21 knots.

These vessels would appear on the scene some fine morning at daylight, with a good head of steam ready, and sink or capture our watchers, as the latter would not have sufficient speed to escape, even under the best conditions.

The fact that our second-class cruisers have not improved in speed during the last ten years, was forcibly pointed out by Admiral Sir John Hopkins a short time ago, in a very interesting and comprehensive paper which he read at the Royal United Service Institution. The increase in size in the more recently built vessels of this class, and the saving of weight effected by the use of water-tube boilers, have been devoted to giving them a more powerful armament, but without giving them any material advance in speed (half a knot nominal, I think it is). It is not for me to criticise this policy. I merely point out that these later vessels do not appear to be any better suited to perform the duties of scouts than their older sisters; in fact, for some reasons, rather less so, as they cost about £50,000 more money.

Our torpedo gunboats have not sufficient speed or seagoing qualities to enable them to act as scouts to our battle squadrons. And, lastly, our destoyers have neither the size, sea-keeping qualities, nor the coal endurance to fit them for the duties, though they are doubtless excellent little vessels for the purpose for which they were intended.

Recent events in South Africa have illustrated the extreme importance of efficient scouting in land warfare, and, if we may reason by analogy, there seems to be cause for believing that scouting will be of at least equal importance in the event of a great maritime war.

I have thought it desirable to enter at some length into my reasons for proposing a vessel of this tonnage, speed and horsepower, with such a very light armament, though I am ready to admit that such vessels are not wanted in peace time.

I now submit the design for your criticisms.

Discussion.

[From "Engineering."]

Captain Clover, U. S. N., was the first speaker. He said that the experience gained by American naval officers during the recent war with Spain was that there was very great need for scouts; they had employed ocean liners for the purpose, and had found them extremely efficient. As a result it had been concluded that it would not be desirable to build vessels especially for such purposes. Such craft must be of considerable size—a ship of 3,000 or 4,000 tons was hardly equal to maintaining speed in heavy weather during long voyages at sea. The ocean liners were, therefore, best fitted as long-distance scouts, whilst destroyers would fill the position of small scouts for closer operations. They ascertained, however, that in order to find the enemy's fleet they had to cruise all over the West Indies. Many vessels were required to form the big fleet of cruisers necessary, and, therefore, they had come to the conclusion that they must depend on the ocean liners, keeping torpedo craft for close scouting.

Admiral Sir John Hopkins would have preferred that Sir William White had spoken first; as, however, he was asked to take part in the discussion he would do so. With all respect to the opinions just expressed by his American friend, he did not think the big ocean liners would be able to carry out the work of scouting against a formidable naval foe; say, for instance, one of these vessels was sent to watch certain straits, they would be chased off by more powerful vessels. We had plenty of 20-knot (measured mile) second-class cruisers, but they would be no good against 21-knot cruisers. Nelson had said that the want of frigates would be engraved on his heart. He needed scouts equal to those they would have to meet, but if they were run down they could not get the information that was needed. It was useless to send a ship into a position of danger of being overhauled and taken. He would always urge something more than 20-knot speed. Years ago Sir William White, with that rare skill which distinguished him, had designed 20-knot cruisers,

but since then he had not gone further in this type of craft. Why, he would ask, was that? He was certain that a naval constructor could progress further if he liked; what, then, held his hand? Captain Mahan had said that rapidity in action was the most pressing need of a cruiser; other points were subordinate. Commander Ballard, an authority on such matters, asked for first-class cruisers to be brought to a speed of 23 or 24 knots, that second-class cruisers should be 22 knots, and third-class cruisers 21 knots. The speaker considered he was a moderate man in going no further. Foreign vessels were designed for 23 knots and were expected to get 24. In face of this, should we not also go higher? In conclusion, he thought the design shown should be built to, as it was the right kind of ship and one we needed.

Captain May, R. N., said he understood that this ship was to be able to run away, with the certainty of escaping a second-class cruiser, but it would be doubtful if it could escape from a first-class cruiser, as it was of small size, and would be unlikely to keep its speed at sea. It could, however, be driven off by a second-class cruiser, but it would, in turn, drive away a third-class cruiser or a destroyer. Suppose, however, ten of these vessels were needed, it would be necessary to go to the House of Commons and ask for 2¾ millions sterling and 3,000 men. Taking the estimate of £100 per head, a very large sum of money would be demanded for ships not able to stand up to anything except third-class cruisers and destroyers. In regard to power, it was always understood in the past that the British frigate should beat a French vessel of the same class, but when America produced frigates more powerful than our own, an order was given that our frigates should not go out excepting in pairs. This vessel proposed was not, therefore, a "Nelsonian" frigate. In regard to scouting, he would point out that the general operation was for the vessel seeking information to endeavor to come up with the enemy's fleet. In closing in she would meet a cruiser, and if the latter were one of the large class she would be driven off, and probably see nothing of the hostile fleet but the one cruiser,

and would, therefore, be unable to report the nature of the enemy's force to the admiral. He did not see much good in the proposed ship, nor how it would fit in.

Sir William White pointed out that about three years ago a proposal was made in France to build two vessels closely approaching Admiral Fitzgerald's design. The vessels were described in detail, and a grant was made; but they were not yet begun, and the grant had not reappeared. There had been in the past considerable discussion as to the value of swift vessels moderately armed, and he thought the balance of opinion was on the side which Captain May had supported. If the size were kept down, and the speed were high, there must be sacrifices, as Admiral Fitzgerald had said. He thought that though 200 revolutions was slower running for the engines than in torpedo craft, it was still high, but the type of boiler could not be used without some falling off at sea, and he considered 23 knots as a sanguine estimate. Still there was a large margin, but he thought 17,000 horsepower would have to be reduced as a continuous speed performance.

Mr. Philip Watts said that in regard to the remarks made by Sir William White, it would doubtless be of interest if he gave figures showing how the displacement of the vessel described by the author was made up. They were as follows:

Hull and fittings,	1,820 tons.
Machinery,	820 "
Protective material,	330 "
Armament,	130 "
Equipment,	150 "
Normal coal,	500 "

The 820 tons was sufficient for two sets of four-cylinder engines, which at 230 revolutions would give 17,500 indicated horsepower. For this, ample steam would be given by 16 Yarrow straight-tube boilers, working at less than three-quarters full power, and at slightly under 200 revolutions they would get a

speed of 23 knots. That would be with 2 inches of air pressure at the outside. Working, therefore, with 75 per cent. of the maximum performance of the boilers, there would be a quarter of the number available for being cleaned. That, no doubt, would be a high performance, but experience with recent ships had shown that it could be realized. If it appeared more than could be done, as probably it might to some, he would state that he had consulted engineers who had most experience in work of this kind. Mr. Marshall had said that the result could be reasonably looked for, and Mr. Robert Humphreys was prepared to undertake the work on these lines. He wished to state that the design shown was not his. His own feeling was that the ship should have a stronger armament. He would like to see at least two additional 6-inch guns, so that the ship would be able to meet a cruiser of the same size; by adding 200 tons to the displacement, two 6-inch guns and submerged torpedo tubes could be introduced; another 200 tons would give eight 6-inch guns in place of two 6-inch guns and six 4-inch guns, the speed remaining the same. The addition to the cost would be about £40,000, an outlay which he thought would be quite warranted by the advantages gained on an original total cost of £270,000.

Professor Biles said that Captain Clover had given the results of practical experience in regard to the advisability of building such ships as the author suggested. The policy of using high-speed steamers as scouts had been questioned by others. He himself had read a paper at the Southampton meeting of the Institution on the possibility of adapting mercantile steamers for war purposes, especially for scouting. He had suggested a way of putting armor on a mail steamer, and so placing her in a defensible condition. Admiral Fitzgerald asked for his design £250,000, but the speaker would build a mail steamer on the lines he suggested for that sum, and which would be as good for war purposes, but would earn money in time of peace. It was for naval officers to settle the need for scouts; but if that exists, Captain Clover's views were important. If they could use mercantile vessels for scouting, the available money under the Navy

Estimates might be devoted to building vessels more intended to fight than to run away.

Admiral Fitzgerald, in reply, said that the whole question turned on whether such vessels as he described were wanted. He wished a number of his friends who had corresponded with him were present to say what they had written in their letters. These were, however, confidential, and could not be quoted. Captain Clover did not think such a ship was necessary, but the speaker would point out that the conditions present during the American and Spanish war were very different to those which we should have to meet in a conflict with a strong power. The Spaniards had no first-class cruisers to chase the mail steamers off. There was, however, in our case another aspect of the question. These high-powered mail steamers, which it was proposed to use for fast scouts, would be needed to bring food for the country, as the 10-knot cargo boats would hardly be able to keep the sea. No doubt in the late war mercantile vessels did well for the American Navy, for their small cruisers were not up to the work.

He thought Captain May had rather strained the question in regard to a scout running away because she met a bigger vessel. One could not expect these craft to go inside an enemy's camp, but it was quite possible to sight the enemy and go back and say he was there. He was exceedingly obliged to Mr. Watts for what he had done in this matter, but he must point out that there must be a limit to increasing size. They had commenced with 2,500 tons, and now he was asked to go to 4,500 tons. A bigger ship meant more money. What they wanted was a vessel to scout and bring in despatches. If they gave her a bigger armament she would be neglecting her duty for the sake of fighting some one else. Sir William White had said that the French had contemplated a somewhat similar vessel, and had then found that they did not want her. That might be very true, but what France did not want England might need. The strategy of the two countries would be different. We looked forward to watching off an enemy's ports; our policy was that we should have command of

the sea. Sir William White had said that 23 knots was too sanguine, and was better than had been done before. That might be true, but it was a habit that Mr. Watts had of doing something that had not been done before. Professor Biles said that merchant vessels specially designed to do the work could be built. The answer to that was that they had not been built.

DATA ON COMPRESSION.

By Mr. A. Geo. Mattsson, Associate.

In the February number of the Journal, Mr. B. C. Ball, in a reply to Mr. Isherwood, presents a set of indicator cards from a stationary engine to show the effect of early compression, and the possibility of compressing the back pressure to a point above the initial pressure in the cylinder, and as an additional illustration, but even more impressive, the accompanying cards prove that this can readily be accomplished.

These cards were taken by myself from the engine of the Steamer *Roumania*, the first triple-expansion engine designed in the Great Lakes district, at the works of Messrs. S. F. Hodges Co., Detroit, in 1886. The cylinders, 20½, 32 and 54 inches in diameter by 42 inches stroke, are all fitted with revolving valves. The sequence of cranks is high, intermediate and low.

The high-pressure cylinder valves had originally ⅛ inch negative lap, resulting in cards No. 4 and No. 5, and as the compression was excessive, the valves were changed at first arrival in port by taking off ⅜ inch from the exhaust edge of valves, with results shown on cards Nos. 15 and 16.

The valves were set with ⅛-inch steam lead, and were worked from crossed eccentric rods. No changes were made in lead or steam laps.

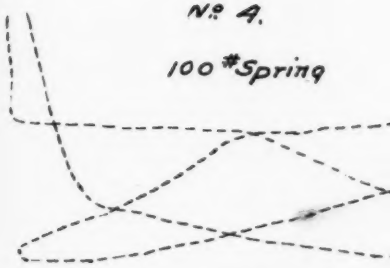
One of the most interesting points in this performance was the fact that previous to reducing the exhaust lap the H.P. cylinder-head joint leaked freely, even with as low a steam pressure as 120 pounds, whereas, after the change no leak was noticeable even at 140 pounds, proving incidentally that a higher pressure was present at first in the cylinder than that due to the boiler pressure.

The pencil of the indicator went beyond the top of the paper, which accounts for the disconnected curve on cards Nos. 4 and 5.

Many other statements have been brought out in this interesting discussion, but my object is simply to submit a fact in this matter.

No. 4.

100 # Spring

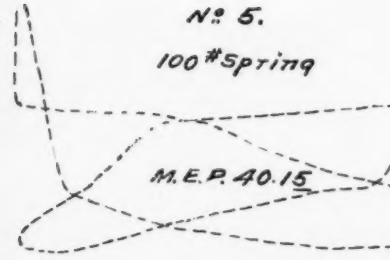


H.P.

71 Revolutions
24" Vac.
134" Steam

No. 5.

100 # Spring



M.E.P. 40.15

72½ Revolution
24 Vac.
140" Steam.

ring

P.

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No. 15.

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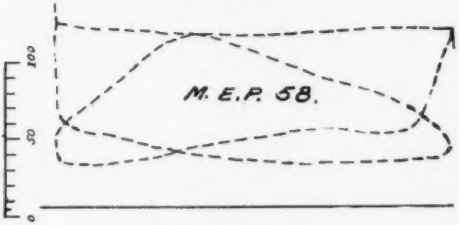

76 Revolutions
Vac. 23½"
Steam. 129#

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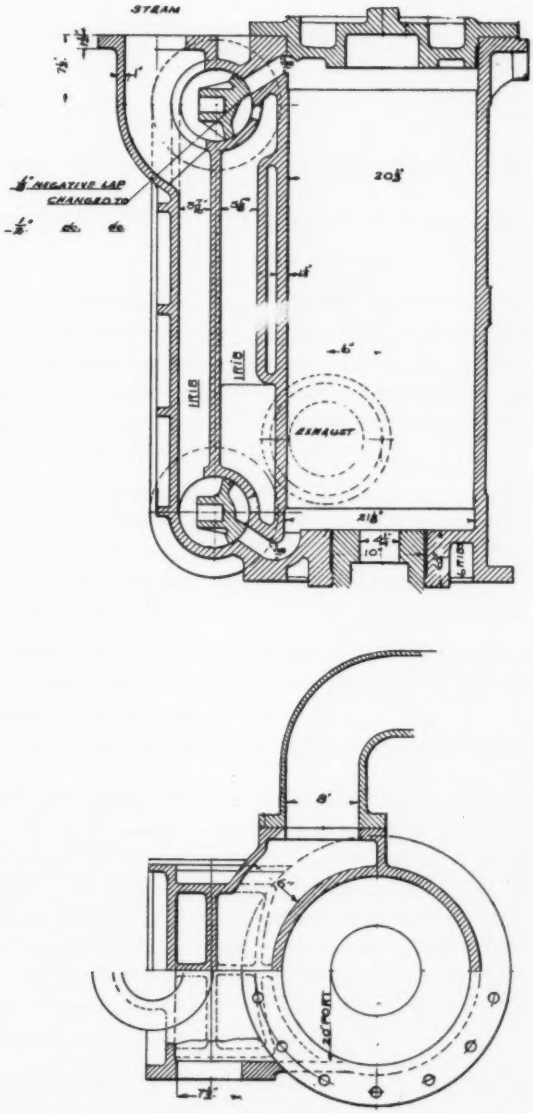
5

tion
m.

No. 16.

100# Spring

77 Revolution
24" Vac.
Steam 140#


STEAM
1/8" NEGATIVE LAP
CHANGED TO
20⅝"
EXHAUST
21⅛"
6"
15"
1⅛"
1⅛"
10"
2⅝"
2⅝"
1⅛"
8"
15"
2nd PORT
7⅛"

STEAM CUTTER FOR THE GERMAN NAVY.

[Translated from "Schiffbau," by MR. A. M. P. MASCHMEYER, Associate.]

The firm of Sachsenberg Bros., Rosslau on the Elbe, recently furnished to the Imperial Dockyard at Kiel, a steam cutter, of which the longitudinal section, deck plans and cross sections are represented in the accompanying plates. The boat was built as a traffic boat for use in the bay of Kiel, and is arranged for towing. The principal dimensions are:

Length from stem to stern, feet, ...	47.6
Breadth over frames, feet, ...	10.43
Depth at side, feet, ...	6.50
Draught, with complete equipment and three tons of coal on board, ...	4.6

The hull is divided by four watertight bulkheads into five compartments. The best German Siemens-Martin steel was used in the construction of the hull.

The division and arrangement of the different rooms is as follows:

In the afterpart of the boat there is a saloon cabin with accommodations for eight people, and aft of this a cockpit with benches. In the center of the hull there is an undivided room for boiler, main engine and equipment, while forward there is a covered cabin with clothing and provisions lockers for six or eight men, besides a watercloset. A compound engine with surface condenser drives a three-bladed, composition screw of 3.28 feet diameter and 3.94 feet pitch.

The dimensions of the engine are:

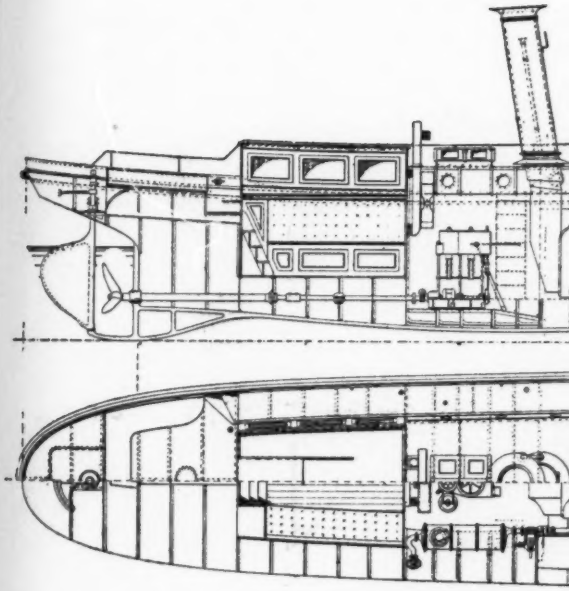
Diameter of H.P. cylinder, inches, . . .	7.28
Diameter of L.P. cylinder, inches, . . .	13.78
Stroke, inches, ...	7.87

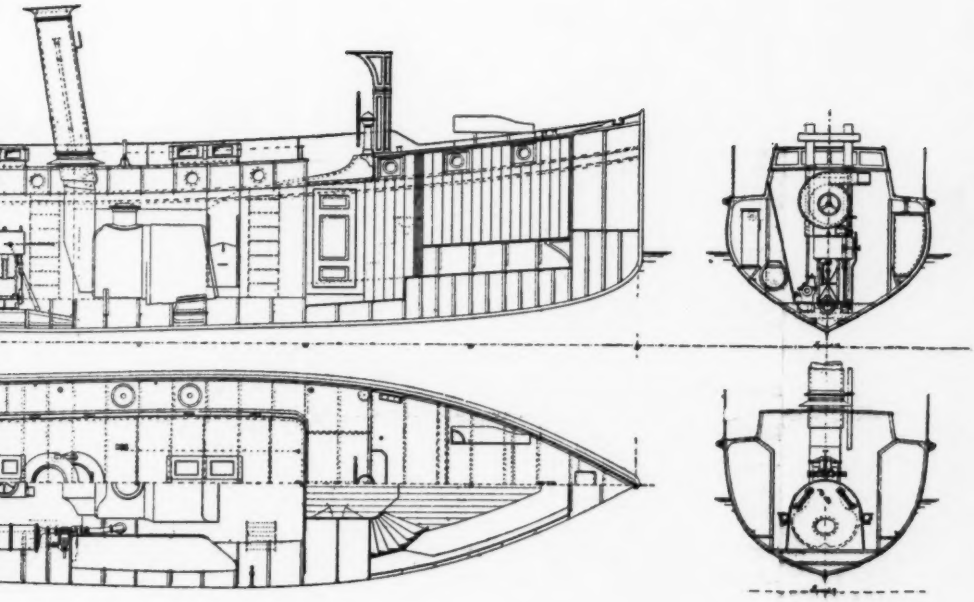
The engine develops 75 horsepower with 150 pounds boiler pressure and 350 revolutions per minute, and 100 horsepower with 370 revolutions at the same pressure. The maximum piston speed is 466 feet per minute. Both cylinders with their chests are cast in one piece. There are no separate steam jackets, but the exhaust steam from the high-pressure surrounds the low-pressure cylinder. Both pistons are of cast steel, while the cylinder covers are of composition. The cylinders are supported by six wrought-iron columns, which are stiffened by stays and tie rods. There are three crankshaft bearings; the after one having four thrust rings. Attention is called to the extremely simple reversing gear, which has often been used in small engines. A single eccentric serves to operate the piston valve of the high-pressure cylinder and the Trick slide valve of the low-pressure cylinder. (See figure.) The position of the high-pressure steam chest gives a small receiver and a short path for the steam to the low-pressure cylinder. The condenser is made of copper and is placed horizontally.

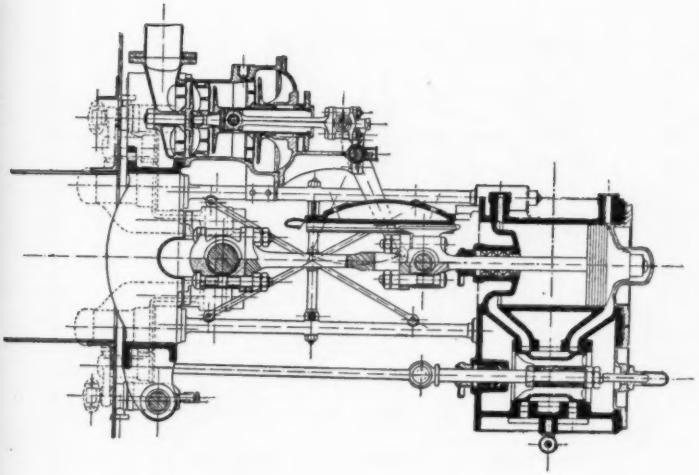
A centrifugal pump driven by a small simple engine circulates the cooling water. On account of the high piston speed, it is undesirable to connect the circulating pump to the crosshead of the main engine, and, therefore, even for this small engine an independent circulating engine is provided. Relieving the crossheads of this work materially reduces the pressure produced by the acceleration of the moving masses. The air pump is made entirely of composition and is driven from the high-pressure crosshead through beams. Two feed pumps, a bilge pump and a water-service pump receive their motion by means of a worm gear from the crankshaft.

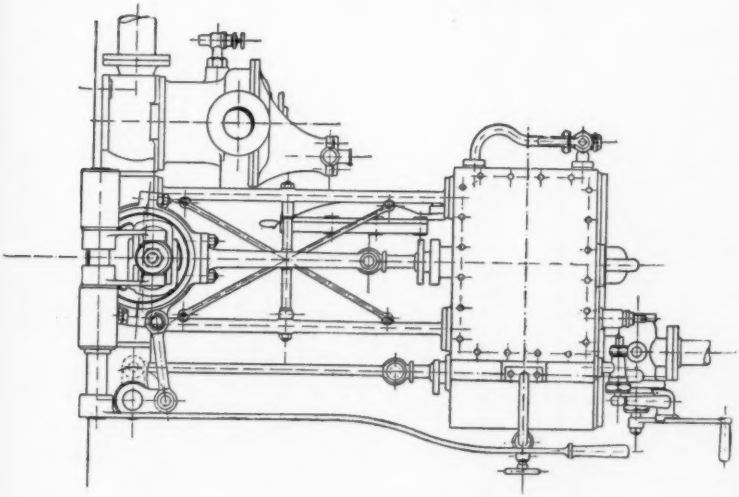
Steam is furnished by a locomotive boiler of 236 square feet heating surface. The grate is forward and is supplied from underneath with air from a blower driven from the main engine. A steam-pump, ejector, feed and fresh-water tanks complete the equipment. On the trial trip the boat made the prescribed 10 knots.

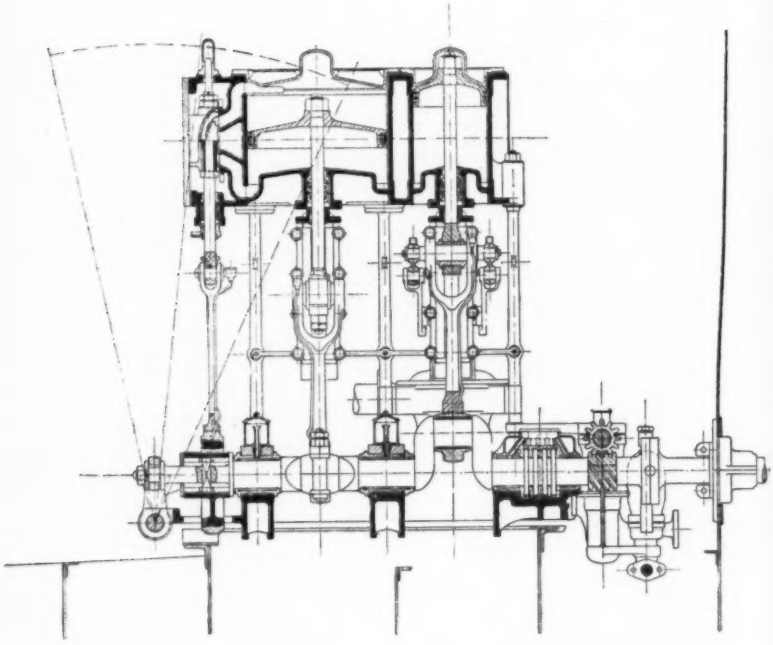
The accompanying table gives the results of the measured-

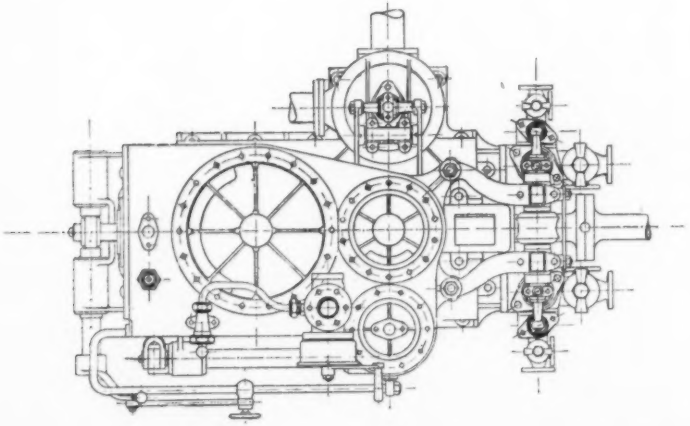




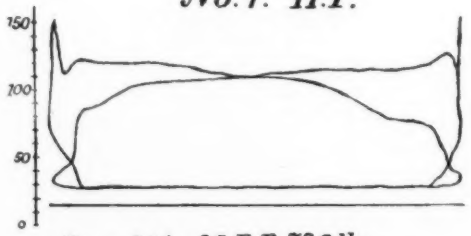






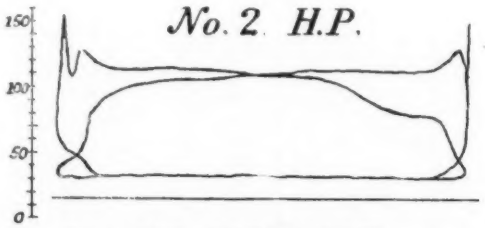


No. 1. H.P.



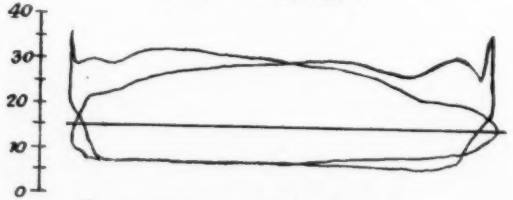
Rev's 344 M.E.P. 73.9 lbs.
I.H.P. 42.6. Vacuum 9.96 lbs.

No. 2. H.P.



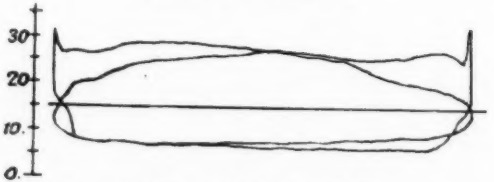
Rev's 336. M.E.P. 69.3 lbs.
I.H.P. 38.9. Vacuum 9.96 lbs.

No. 1. L.P.



Rev's 344. M.E.P. 19.3 lbs
I.H.P. 39.9 Vacuum 9.96 lbs.

No. 2. L.P.



Rev's 336. M.E.P. 17.3 lbs.
I.H.P. 35.0. Vacuum 9.96 lbs.

mile trials made in the bay of Kiel, August 1, 1900. The four indicator diagrams were taken during these trials.

Number of run	1	2	Mean.
State of the sea	Slightly disturbed.		...
Wind, direction	W.	W.	W.
force	3	3	3
Course steered	N.E. $\frac{1}{2}$ E.	S.W. $\frac{1}{2}$ W.	...
Time on course, minutes and seconds	6–5	6–24	6–14.5
Number of diagram	1	2	...
Mean effective pressure, H.P.	73.96	69.26	71.6
L.P.	19.34	17.35	18.35
Indicated horsepower, H.P.	42.6	38.9	40.75
L.P.	39.9	35.0	37.45
Total	82.5	73.9	78.20
Speed in knots per hour	9.863	9.375	9.619
Slip of screw, per cent	26.2	28.2	27.2
Air pressure, inch of water	.4	.5	.45

THE VIBRATION OF STEAMERS.

ON SOME EXPERIMENTS MADE ON BOARD THE ATLANTIC LINER *DEUTSCHLAND*, DURING HER TRIAL TRIP IN JUNE, 1900.

[Abstract of a paper read before the Institution of Naval Architects.]

By Herr Otto Schlick.

The principal cause of vibrations in steamers, so far as these consist in the bending of the ship's axis in a vertical plane, is well known to lie in the action of the up-and-down moving machine parts in a vertical direction. To prevent these vibrations it is absolutely necessary to use an engine with balanced forces, or, as it is usually termed, a balanced engine. It has been found that this precaution is not only necessary for men-of-war, and passenger ships of proportionally high engine power and speed, but even in cases of large cargo steamers of medium speed. On account of the varying displacement of this latter type of vessel, the so-called "critical number of revolutions" varies to such an extent that it is not always possible to arrange the number of revolutions of the engine in such a way as to prevent vibrations, which under circumstances have proved to be a great drawback to the rigidity of this class of ship.

It has repeatedly been found that even a vessel provided with a carefully-balanced engine has still shown slight vibrations at the critical number of revolutions of the engine, although in a considerably less degree than in vessels with unbalanced engines. I particularly emphasize that only vibrations are dealt with here, the period of which coincides with a revolution of the engine.

Most of the vessels supplied with my system of balanced engines have been run for trial with the propellers uncoupled to examine the effect of the balancing. On all these trials vibrations have never been noticed, even when the engine reached the critical number of revolutions; whereas engines not balanced

always show excessive vibrations when running with disconnected propellers, as soon as the critical number of revolutions is reached.

The results mentioned here, in short, prove the efficacy and importance of the balancing of forces, but they also prove that the cause of vibrations in vessels with balanced engines does not lie in the engines themselves, and must be sought elsewhere.

It has been tried, especially in Germany, to attribute the cause of the vibrations in steamers with balanced engines to the uneven rotation of the engines, and, in consequence, of the propellers also. One concluded that the variations existing in the speed of rotation of every engine cause a jerking effect in the pressure given by the propeller, and that this pressure acts like the power exerted by a rower in a boat. As the direction of the pressure produced by the propeller does not go through the center of gravity of the ship—according to the views of the defenders of this theory—a bending of the ship's hull in its longitudinal axis must take place, which produces vibrations when regularly repeated.

There are a great number of arguments which prove the incorrectness of these statements, but it would be going too far to enter into all of them here. I will, therefore, only state, as an easily understood proof to the contrary, the fact that vessels with engines of great variation in their speed of revolutions have repeatedly shown no measurable vibrations; while, on the other hand, vessels with an exemplary even-turning speed showed considerable vibrations.

To investigate the real cause of the vibrations in vessels with balanced engines, I considered it necessary to make accurate experiments as to the position in which the cranks of the two engines are to be found when the vibratory movements are in a certain point of the swinging track, *e. g.*, when the axis of the hull of the ship is in its mean position. The results of these experiments promised far-reaching disclosures as to the circumstances accompanying these vibrations, which up to now have quite passed our notice.

Through the kindness of the Stettiner Maschinenbau Actien

Gesellschaft Vulcan I was enabled to make the before-mentioned experiments on the trial trip of the steamer *Deutschland.*

* * * * * * *

HORIZONTAL VIBRATIONS.

The horizontal vibrations are attributed to torsional vibrations, as I have already repeatedly explained in other places.

All diagrams show that during one revolution four complete torsional vibrations occur. They show the exact number of vibrations during one revolution as the propeller has blades. This is an occurrence which is to be found in all twin-screw steamers, and which must, without doubt, be attributed to the action of each propeller blade. It has always been observed that, when another propeller with a different number of blades was put on, the number of the horizontal vibrations varied accordingly.

CONCLUDING REMARKS.

If we sum up the results of the foregoing researches we have to record the following:

The critical number of revolutions for the vertical and horizontal vibrations has been pretty accurately ascertained.

It has been proved that the slight vertical vibrations are neither caused by mistakes in the balancing of the masses, nor by the variations in the turning moment, or speed of revolution.

It has been ascertained that the vertical vibrations are caused by a somewhat greater resistance in one blade on each propeller, and it has been shown which these blades are. The cause of the maxima and minima vertical vibrations have been found.

It has been proved that each propeller blade finds its greatest resistance in revolving when rising outwards at an angle of about 30 degrees to the horizontal position. It has further been ascertained that the horizontal vibrations are also caused by the propeller blades, and that the number of the maxima and minima which occur during the time that one engine makes exactly one revolution more than the other depends upon the number of blades. The variations in the turning moments of the engines have no influence on the horizontal vibration.

Finally, the conclusions we have been enabled to draw from the appearances of the vertical vibrations, viz.: that one blade on each propeller meets with a greater resistance when turning than the others, are also confirmed by the curves of the horizontal vibrations. These results agree on the whole with those which have been made by me on other vessels.

The greater resistance of the one blade, of which we have repeatedly spoken, is probably in most cases to be attributed to the greater pitch of the same. The least deviation in the pitch, which cannot be proved by ordinary instruments, appears to be sufficient to cause perceptible vertical vibrations. The greatest care must therefore be taken in the manufacture of propellers, not only for the sake of preventing vibrations, but also for saving power, and in order to prevent blades from breaking.

THE MARINE STEAM TURBINE.

By C. A. Parsons.

[Abstract of paper read before the Institution of Engineers and Shipbuilders in Scotland.]

At a meeting of the Institution of Engineers and Shipbuilders in Scotland, held on February 19, a paper on "The Marine Steam Turbine and its Application to Fast Vessels," was read by the Hon. C. A. Parsons. It was illustrated by lantern views.

Mr. Parsons said the advent of the dynamo electric machine, and the development of mechanical and electrical engineering, created a demand for a good high-speed engine, and in 1884, a compound steam turbine engine of 10 horsepower and a modified high-speed dynamo were built for a working speed of 18,000 revolutions per minute. This machine was now in South Kensington Museum. This turbine engine consisted of two groups of fifteen successive turbine wheels, or rows of blades on one drum or shaft within a concentric case on the right and left of the steam inlet, the moving blades or vanes being in circumferential rows projecting outwardly from the shaft, and nearly touching the case, and the fixed or guide blades being similarly formed and projecting inwardly from the case and nearly touching the shaft. A series of turbine wheels on one shaft were thus constituted, each one complete in itself, like a parallel-flow water turbine, but, unlike a water turbine, the steam after performing its work in each turbine passed on to the next, preserving its longitudinal velocity without shock, gradually falling in pressure on passing through each row of blades and gradually expanding. Each successive row of blades was slightly larger in the passageway than the preceding, to allow for the increasing bulk of the elastic steam, and thus its velocity of flow was regulated so as to operate with the greatest degree of efficiency on each turbine of

the series. All end pressure from the steam was balanced by the two equal series on each side of the inlet, and the revolving shaft lay on its bearings revolving freely without any impressed force except a steady torque urging rotation, the aggregate of the multitude of minute forces of the steam on each blade. It constituted an ideal rotary engine, but it had limitations. It was perceived that these defects would decrease as the size of the engine was increased, with a corresponding reduction of rotational velocity, and consequently efforts were made towards the construction of engines of larger size, which resulted, in 1888, in several turbo-alternators of 120 horsepower being supplied for the generation of current in electric-lighting stations, and at this period the total horsepower of turbines at work reached in the aggregate about 4,000, all of which were of the parallel-flow type and non-condensing.

In 1892 the compound steam turbine was first adapted to work in conjunction with a condenser. The first condensing turbine was 200 horsepower and, at a speed of 4,800 revolutions per minute, drove an alternator of 150 kilowatts output, and soon afterwards several of 600 horsepower of the non-condensing parallel-flow type were set to work in the Metropolitan Companies' stations, where the comparative absence of vibration was an important factor. Turbine alternators and turbine dynamos of 2,000 to 4,000 horsepower are now in course of construction in England, on the Continent, and in the United States, and larger sizes are being designed. The most important field, however, for the steam turbine was undoubtedly in the propulsion of ships. The large and increasing amount of horsepower, and the greater size and speed of the modern engines, tended towards some form which shall be light, capable of perfect balancing and economical in steam. The marine engine of the piston type did not entirely fulfil all these requirements. In January, 1894, a pioneer syndicate was formed to explore the application of the steam turbine to marine propulsion, and for this syndicate the *Turbinia* was built in 1894; and the result of experiments with this vessel having proved satisfactory, two torpedo destroyers had been built since that date for the Ad-

miralty, viz.: the *Viper*, by the Parsons Marine Steam Turbine Company, and the *Cobra*, by Sir W. G. Armstrong, Whitworth and Co. The *Viper* had passed all her official trials and had fulfilled all the guarantees of her contract. As regards speed, she had exceeded the 31 knots guaranteed by over 5 knots, and as regarded the guarantee of 2.5 pounds of coal per I.H.P. at 31 knots she easily obtained a consumption of 2.38 pounds. The *Cobra* had duplicate machinery to the *Viper*, and was now the second fastest vessel afloat.

As to the future, though, for obvious reasons, up till the present turbines had only been fitted in vessels designed for phenomenal speeds, yet it must not on this account be assumed that they are only applicable to such vessels. The two conditions of suitability are that the vessel shall have a moderately fast speed and be of moderately large size. For slow vessels of moderate and small size the conditions for turbine machinery are not at the present time so advantageous. The class of vessels that were most suitable for the application of turbine machinery are the following: Pleasure steamers, passenger and cross-channel steamers, liners (including Atlantic liners of the largest size), also all fast war vessels, such as torpedo boats, destroyers, cruisers of all sizes, protected cruisers and all battleships of the usual speeds.

Proceeding to consider some of the applications of the steam turbine more in detail, Mr. Parsons took first the vessel now building by Messrs. W. Denny and Brothers, of Dumbarton, for the Fairlie-Campbeltown service, which it was hoped would be ready by July 1st, the dimensions of which are—Length, 250 feet by 30 feet beam, by 10 feet 6 inches molded to main deck, and 17 feet 9 inches molded to promenade deck. The general arrangements are somewhat similar to the *Duchess of Hamilton*, and to those of the usual modern type of river or coasting pleasure steamer, but slight modifications have been introduced to suit the turbine machinery. The machinery consists of three separate turbines driving three screw shafts. The high-pressure turbine is placed on the center shaft, and the two low-pressure turbines each drive one of the outer shafts. Inside the exhaust

ends of each of the latter are placed the two astern turbines, which are in one of the low-pressure motors, and operate by reversing the direction of rotation of the low-pressure motors and outside shafts. In ordinary ahead going the steam from the boilers is admitted to the high-pressure turbine, and after expanding it about 5-fold, passes to the low-pressure turbines, and is again expanded in them about 25-fold, and then passes to the condensers, the total expansion ratio being about 25-fold, as compared with from 8 to 16-fold, usual in triple-expansion reciprocating engines.

At 20 knots the speed of revolutions of the center shaft will be 700, and of the two outer shafts 1,000 per minute. When coming alongside a jetty or maneuvering in or out of harbor, the outer shafts only are used, and the steam is admitted by suitable valves directly into the low-pressure motors, or into the reversing motors for going ahead or astern, on each side of the vessel. The high-pressure turbine, under these circumstances, revolves idly, its steam-admission valve being closed, and its connection with the low-pressure turbines being also closed by non-return valves. By this arrangement great maneuvering power is obtained, and though similar to that adopted in the *Viper* and *Cobra*, it has some distinctive advantages, especially as regards the reversal of the outer instead of the inner shafts, yet, it should be stated that the officers in charge of the *Viper* have described her as an extremely handy vessel of her class. The main air-pumps are compound and worked by worm gearing from the main engines in the usual way. There are also small auxiliary air-pumps worked from the circulating engines for draining the condensers before starting. The other auxiliary machinery is that usual in vessels with reciprocating engines, and includes a feed heater fed from the exhaust steam of the auxiliaries, and also when necessary by steam drawn from an intermediate point in the expansion of the main turbines. The boiler is of the usual double-ended Scotch pattern. The speed of the vessel is expected to surpass that of any similar boat at present on the Clyde. In vessels of the mercantile marine of moderate fast speed it was of more importance to obtain economy in coal

consumption than to reduce the weight of the engines and condensers to their lowest limit, as was usually done in torpedo-boat destroyers, where the boilers were extremely light and heavily pressed, and the highest possible speed was the first consideration. For the mercantile marine, therefore, it became desirable to design the turbines for the greatest possible economy in steam, consequently the ratio of expansion extended over nearly the whole range between the boiler pressure and that in the condenser; the condensers were also of ample size, so as to maintain a good vacuum, and an efficient feed-heating arrangement was provided to warm and heat the feed. These economical measures were being introduced in the vessel now building by Messrs. Denny Brothers, as well as in a new destroyer building by the Turbinia Company. The marine steam turbine would, he said, be found to be superior, or at least equal in economy of coal, to the reciprocating engine when placed in fast vessels of the mercantile marine; but it might be asked, what would be the economy of the turbines when, as in the case of yachts and almost all war vessels, much steaming was to be done at from one-eighth to one-tenth power, the full power being only occasionally used? The answer was a simple one. At cruising speeds the revolutions of the turbines fell within the limits of speed of small reciprocating engines, and such small engines were then directly coupled to the main turbines, and worked in conjunction with them, these small triple-expansion reciprocating engines taking the steam direct from the boilers, and expanding it down to about atmospheric pressure, it then passed to the high-pressure turbine, and thence through the low-pressure turbines to the condensers. When somewhat higher speeds and powers were required, and the speed of revolution rose beyond that permissible for the reciprocating engines, the stop valve was closed, the coupling opened, and the turbines alone drove the vessel. This combination of machinery permitted the full range of expansion of the steam at cruising speeds, and the economy in steam and coal would be superior to that of the best ordinary reciprocating engines at reduced or cruising speeds.

The arrangement of turbine machinery for an Atlantic liner of 20,000 to 30,000 I.H.P. presented no features of novelty over the preceding designs, but its simplicity of construction, as compared with the present usual reciprocating engine, was more apparent than in the case of smaller vessels. For a 22-knot liner of 23,000 I.H.P., the speeds of revolution sank to about 300 and 420 on the inner and outer shafts respectively, and the consumption of coal will be less than was at present required for the same displacement and speed. The principal advantages of the turbine system of propulsion for fast pleasure steamers and passenger steamers of all classes, compared with vessels fitted with ordinary engines, are, in conclusion, summarized as follows: 1. Increased speed for the same boiler power, due to considerably reduced weight of machinery and increased economy in steam. (This advantage increases with higher powers and speeds.) 1a. Same speed with reduced boiler power and reduced coal consumption for the same reason as par. 1. 2. Absence of vibration, giving greater comfort to passengers. 3. Increased cabin accommodation, due to smaller machinery space. 4. Less upkeep in machinery and smaller engine-room staff.

In the discussion which followed **Mr. Archibald Denny** said that, having heard Mr. Parsons speak on the same subject three years ago, he was so impressed with the turbine that he ordered one for driving the dynamos on the *Duchess of Hamilton*. Being ambitious to work with Mr. Parsons for the success of the turbine, his firm got in touch with him with the view of having it applied in the mercantile marine. They approached the railway companies in the first instance, but each company was anxious that somebody else should make the experiment. So the matter was hung up, and he was beginning to despair when Captain Williamson came forward and lent them aid. The three of them having laid their heads together, they resolved to build a mercantile turbine vessel. They did not guarantee anything, but they expected to get from this vessel 20 knots, an increase of 2 knots on the *Duchess of Hamilton*. This was nothing like 36 or 37 knots, but they were not building a torpedo-boat destroyer.

In answer to a question as to how the consumption of steam

was determined, **Mr. Parsons** stated that it had been determined in connection with the use of turbines for driving dynamos.

One speaker remarked with reference to the practical application of the turbine on steamers on the Clyde, that in the case of the *Turbinia* it was found that she could be brought to rest in 30 or 40 seconds. But if the vessel was traveling at 36 knots an hour that implied that she would have traveled 900 feet. No such speed could be traveled by a river boat, but some time would be taken to bring up even a 20-knot boat, and if she was running in and out continually this would have a considerable effect in taking off the increased speed, though it would not be of so much importance in channel steamers.

Prof. Jamieson said he should like to ask Mr. Parsons a few questions. In the first place, what were the different causes for using highly superheated steam in reciprocating engines and in steam turbine engines? The former was, he believed, to minimize condensation in the cylinders, and the latter to minimize friction between the steam and the surfaces of the rotating and fixed passages; and both resulted in the use of less weight of steam per I.H.P. and much less coal burned, the former, however, demanding care in the use of high-flash lubricants, whereas in the latter no such care was necessary. In the second place, he desired to know if the use of very highly superheated steam in the turbines showed any signs of cutting any of the surfaces along which it passed. Again, if ordinary saturated steam were used to begin with in the high-pressure section of the turbines, what was its condition just before entering the condenser (*a*) at full speeds, (*b*) at low speeds, and (*c*) when using steam superheated at 50, 100 and 150 degrees Fahrenheit? In the fourth place, what percentage of loss of propelling effect might be entailed by inclining the screw shaft to such an angle as the model of the Clyde steamer showed, and gained by thus having the screws more deeply immersed? What was the net gain or loss?

Another point he wished to raise was concerned with gearing. When he was an apprentice at Aberdeen, in 1865–6, he fre-

quently saw the engines of a steamer wherein stepped wooden cog-wheel gearing was employed to raise the revolution of the screw above the naturally slow speed of the engines. Mr. Parsons could easily adopt such gearing, but with the reverse object—to bring the high speed of the turbines down to the required slower speeds of the screws in tramps and other comparatively slow cargo boats. There need be no noise or backlash with thoroughly well-made and fitted stepped gearing. His final question was, Had other methods of reversing the screws been tried than that of a separate reversing turbine?

Mr. Alexander remarked that Mr. Parsons had said of the *Turbinia:* "Since she was completed she has run several thousand miles, sometimes in very heavy seas, and the main engines have never caused a moment's anxiety, nor have any repairs to them been required." It was important that they should know what that exactly meant. A ship running at 30 knots would not take more than a fortnight to cover several thousand miles, and in so very short a period her engines would not have time to deteriorate. There was an ugly rumor that the turbine did deteriorate, and it would be interesting, therefore, to hear from Mr. Parsons how the turbines in use in electric-lighting stations fared.

Mr. Parsons, in replying to the discussion, said he thought that the calculation as to the distance in which a turbine vessel could be brought to rest was too much. But a comparison of the *Turbinia* and an ordinary paddle steamer was valueless, for there were too many complex intermediate data. For instance, the thrust of the *Turbinia's* propellers at full speed amounted to one-ninth of the weight of the vessel; and in any 18-knot ordinary vessel of, say 500 tons displacement, it would not exceed one two-hundredth. They had some comparative data, however, as to the *Viper,* which was brought to rest from 30 knots in about the same time as an ordinary 30-knot destroyer. The time could have been very much shortened had it been desired to do so, but the usual Admiralty intervals were attained with great ease, the valves were operated very leisurely, and only about one-half full

steam was admitted to the reversing motors. In reply to Professor Jamieson, he might say that many of their steam turbines had been in use with superheated steam for the past three or four years, and no deterioration of the blades or surfaces was observable. In some cases a superheat of as much as 150 degrees Fahrenheit above the temperature of the boiler had been used. Generally speaking, a superheat of 50 degrees Fahrenheit reduced the steam consumption by 9 per cent., and a superheat of 100 degrees Fahrenheit by about 12 per cent. At full powers the steam became saturated after a portion only of the expansion, the exhaust steam being saturated, but at light loads the steam was superheated throughout right into the condenser. The diminution he had stated arose partly by annulling of liquid skin friction and partly by the great volume and intrusive energy of the steam. As to the effect of inclination of the screw shaft to the direction of its motion through the water, no exact data were available apart from those derived from observations of model propellers and the calculated behavior of a propeller whose axis was set at a small angle to the direction of motion. Such a small angle as was adopted in turbine vessels had probably no material effect on the efficiency of the propeller, while it had a decidedly beneficial effect on the after propeller when two were placed tandem on one shaft, as a large part of the wake of the forward propeller passed clear of the after propeller. Where direct coupling was possible he did not think gearing would come in for any but small powers. A great many methods of reversing had been carefully considered, but he did not think that any could be compared to that which they had adopted. In reply to Mr. Alexander he had to say that in four years the *Turbinia* had run about 34,000 miles, and there had been no deterioration at all. One of a number of turbines put down in Newcastle in 1887, was opened out last year, and when examined by a microscope was found not to have deteriorated in the slightest. That had been their experience right through; with clean steam there was no wear whatever. The steam pressure in the case he had cited was 80 pounds.

Mr. Hall Brown's question of cavitation was a complicated

one. The efficiency of the propellers seemed largely dependent on the thickness of the blade, as well as the pressure of the water and the proportion of the blade area to the disc area. It would be interesting to get the efficiency of three propellers set tandem on a shaft put at different inclinations. The forward propeller in the earlier vessels was 10 per cent. less in pitch than the after one, but they did not think there was much in that, and were making them all alike now. In their own works they had not a single case of a blade of a turbine out of repair, and they had 140,000 indicated horsepower and a large number on hand. But his impression was that water went through like spray, and did not bring them up sharp. A five-eighths nut had got chewed up the other day and had not hurt the turbine in the least. As to the application or want of application of the turbine to cargo boats, he could only say that in the initiatory stages it was wiser to put the motor to the work for which it was best suited. One thing at a time was quite enough. He was asked how, when rapidly accelerating or retarding speed, the steam balance was maintained. The answer was by the acceleration or otherwise of engine, propeller and shafting. A speed was immediately got up at which the pressure on the blades was equal to the steam pressure on the turbine, and then it remained fairly constant. And it was only for an instant. There was a great amount of thrust in the turbine itself which was quite capable of withstanding any pressure of that kind.

In reply to Mr. Cleghorn, he might say that the weight of the *Turbinia's* engines was 100 horsepower to the ton, of the *Viper's* 70 horsepower, and of the ordinary destroyer's 54 horsepower. That was engines and boilers. The weight of the *Turbinia's* engines alone was 4½ tons. When they got to highly economical boats with large condensers the weights got nearer, but with boats like the *Viper* they were very considerably less. It was a question whether to economize weight in boilers or in engines. As to the amount of repair necessary, he could only say that the *Turbinia's* turbines had only once been cleaned, and the *Viper's* had never been opened except for the Admiralty inspection. The accounts of the lighting companies showed 2½ per cent.

per annum for the whole of the machinery. A certain amount of new machinery would be required for making turbines, but the cost would not be very serious. The noise was objectionable. But at speeds like 1,000 or 1,500 revolutions there was no noise; only a sound like a gale of wind. With ordinary care there was much less liability to derangement in turbines than in ordinary engines, and especially with superheated steam.

The Chairman, in moving a vote of thanks to Mr. Parsons for his paper, said, with regard to the cutting action of the steam, that Messrs. Denny had written to over twenty stations for information on the subject, and had been assured from all that there was no cutting and that the upkeep was extremely moderate.

NOTES.

BALANCED SECTIONAL DRYDOCK.

The following details of a drydock designed for Messrs. Tietjen & Lang, New York, is from an illustrated description of it in "Engineering News" by Mr. Wm. T. Donnelly:

When, in January, 1898, Mr. Lang presented to us [Messrs. Faber du Faur & Donnelly.—ED.] the general proposition to build a sectional floating drydock, capable of handling vessels of 500 feet in length, and to have a maximum lifting capacity of 10,000 tons, which meant an increase in lifting power of about four times the capacity of anything hitherto built, we were more interested in the details of the problem than in the general proposition, and as we pushed our investigation we were pleased to find that our client had a keen insight into and a thorough understanding of the many conditions and difficulties presented.

DESCRIPTION.

The Lang balanced sectional drydock is composed of five sections, each of the following dimensions: 110 feet 10 inches wide, and 80 feet long. When coupled together they are separated by twenty inches, and the section at each end has an overhang of 30 feet, making an overall length of 466 feet 6 inches. The depth at the center is 13 feet 6 inches, and at the waterways 12 feet 6 inches. The height of the wings is 39 feet 9 inches. The draught of the dock light is approximately 4 feet 6 inches, the maximum draught which can be lifted 26 feet, and the maximum lifting power 10,000 tons. The available width between wings is 92 feet.

Pumping Machinery.—The pumping machinery consists of duplicate sets on opposite sides of the dock, each composed of two 125-horsepower vertical boilers, operating engines with cylinders 20 inches diameter and 24 inches stroke, and making 150

revolutions per minute. Each engine drives a line shaft, which runs the entire length of the dock. These operate 6 pumps on each side of each section, or a total of 60 pumps. The pumps are 16 inches square by 20 inches stroke, and as they are driven by a reduction gear of one to two from the engine shaft, they make 75 strokes per minute. This machinery is designed to pump the full capacity of the dock in 45 minutes.

The sections are coupled together by what are known as locking logs, which connect the sections together through keepers. These logs are of oak, 40 feet long and 24 by 28 inches in section.

The essential principle embodied in the Lang balanced sectional drydock and that which has made a floating dock of this size possible, is the manner in which the sections are divided into watertight compartments. The separate sections in the previous sectional drydocks were without transverse bulkheads, and any inclination of a section in a longitudinal direction would cause the water to flow towards the lower end and increase the difficulty of the unbalanced condition. In the Lang dock this has been overcome by building two transverse bulkheads in each section and providing independent means for pumping each compartment. This results in giving to the sectional drydock the desirable features of the present balanced dock, and at the same time retaining many desirable features of the sectional dock.

Machinery.—The choice of machinery for this class of drydock involved the consideration of a great many questions, and results were only arrived at by a series of eliminations. We were fortunate in this instance in having the guidance of all that had been done in and about these waters, and the requirements or conditions that the machinery must meet have been pretty well threshed out. Simplicity and reliability are of the first importance, and economy or efficiency which more often heads the list in large engineering work, is here the last thing to be considered. When it is understood that the machinery at the most will be used but one or two hours in the twenty-four, and more often only once in several days, the small importance of steam economy is apparent. Therefore, in selecting the type of engine, we chose the simple, direct-acting vertical engine of ample power

and of great strength and solidity. The boiler question was limited to such types as could be handled in the extremely limited room on the top of each wing, and the upright type with vertical tubes and submerged steam dome was considered to meet the conditions most satisfactorily. The question of pumps is one that is very broad, and after going over the ground carefully, we became thoroughly convinced that the type of pump which has quite generally been used on these docks, and which the Tietjen & Lang Co. used on all of their other docks, possesses qualities of simplicity and durability that cannot be excelled by more modern and perhaps more mechanical appliances. This pump is a square wooden box made of 4-inch oak planking 16 inches square inside and about 14 feet long, or reaching from the bottom of the dock up through the floor of the pump well a short distance above the deck. There are two of these pumps for every transverse compartment of the dock. They are single acting and each is provided with a foot valve near the bottom of the pump barrel. The foot valve and plunger are made from the same pattern, and are practically gridiron valves, with a rubber diaphragm. The foot valves drop into a taper seat near the bottom of the pump barrel, and the plunger is attached to the lower end of the pump rod. The packing of the plunger is of 4-inch leather belting secured at its lower edge by rivets and free at its upper edge to press against the pump barrel. These pumps have been found to have exceedingly long life, and the parts to be replaced in case of wear or breakage are very simple and inexpensive. The pump rods are connected to a rocker arm, and on one end of this rocker arm is attached a connecting rod operated by a crank on the end of a shaft driven from the main line shaft. The pump rods are of 4-inch I-beam, and the connecting rods of 5-inch I-beam. The boxes at the upper end of the pump rod and each end of the connecting rod are of bronze and are duplicates. The crank shaft and line shaft at the point where the reduction of speed is effected are carried in two stands, and the bearings for both line shaft and countershaft are made from the same pattern, and by means of these stands the distances between centers of the gear are accurately maintained.

The object of referring to these details is to show the effort which was made to effect the greatest possible duplication of parts. In proportioning the machinery for the work to be done a large factor of safety was used, as a break in any of the machinery during the lifting of a vessel might involve a loss of much time, an item of the greatest value in the case of large vessels. The great duplication of parts makes it possible to effect any repairs quickly and with very few parts on hand.

A special problem was involved in the transmission of power from one section to another. When it is understood that a section may have a relative movement only limited by the locking log, and that this movement may be in any direction, it will be apparent that the connection must be both a universal joint and a slip coupling: a universal joint, so that the shaft may turn when out of alignment, and a slip joint so that the sections at this point may come together and separate without interfering with the transmission of power. As the slip coupling must operate under the strains of power transmission, it is necessary to provide a thrust bearing to each section. This was accomplished by securing a flanged hub to the shaft and bolting securely to the top of the dock a cast-iron plate or shoe which engages the flange of the hub and prevents longitudinal movement of the shaft. The slip joint was made of a square shaft, and all the parts of this joint and the universal joint are of cast steel.

The flood gates of the dock have an opening 12 inches square, and the closing slide is made with a taper at each side of the back, so that when forced down by a rod it will be wedged tightly against its seat. The operating rod runs up through the side of the wing, and the gate is raised and lowered by a wheel operating a bronze nut on the upper end of the gate rod.

In operating the dock, the engine and all the pumps are running all the time, and the desired lift to correspond to the weight of a vessel over any compartment of the dock is obtained by a greater or less closing of the floodgate corresponding to that compartment.

In this class of dock (wing docks) the wings or sides have to be built high to admit of deep-draught vessels over the keel

blocks, and to carry the large and heavy machinery used in pumping. Also sufficient displacement or bulk must be given to them to insure the stability of the dock and vessel. To overcome the buoyancy of the dock it is necessary to load it with stone ballast, which is placed in the wings, amounting to 5 tons per running foot, or 400 tons per section in the dock now under consideration. With these points in mind it may be seen that, starting with the dock down and a vessel over the keel blocks ready for docking, the sequence of conditions is about as follows:

1st. The interior and exterior levels of the water are about the same, as just enough ballast has been added to sink the dock to this level, and the dock is practically free from strains.

2d. The flood gates are closed and the pumps lower the interior level of the water, and the vessel is raised to a degree corresponding to the amount of water pumped out, but as the area of the wing is small relatively to the midship area of a vessel corresponding to the maximum lift of the dock, the drop of the interior level of the water will be much more rapid than the rise of the vessel and dock out of the water, and the difference will continue to increase until the wings are pumped out down to the level of the body of the dock, when it will be about 16 feet, which will correspond to a buoyancy or lifting power of 6 tons per running foot of the dock for each wing, or 18 tons for each wing per truss.

The condition of the loaded truss would now be 36 tons concentrated load at the center and a counter strain of 18 tons at points about 7 feet from each end. With the proportions of truss here used, this would give a maximum strain at the center of the lower chord of 72 tons.

3d. From this condition there will be a rapid change, as the lowering of the water in the interior of the dock will be over its entire area, and as this is much greater than the area of the water line of the ship, especially as the immersed body of the ship decreases rapidly per foot of elevation. Consequently the difference of the interior and exterior levels of the water will rapidly grow less, the ship and dock rising much faster than the level of the interior water is lowered. This change will continue until

the dock is entirely pumped out, when, if the lift has been to the maximum capacity, the dock will be just clear of the water, and the load upon it will correspond to the amount of displacement pumped out between the interior and exterior levels of the water at this time, less that necessary to float the dock at this level.

THE NEW DRYDOCK AT BALTIMORE.

A new timber drydock has recently been under construction at the yards of the William Skinner & Sons' Shipbuilding and Drydock Company of Baltimore. The contracts for the dock, pumping machinery, boilers and steel caisson were awarded in June and July, 1899, and the work has progressed fairly well.

The dock is located at the northerly side of the shipyard, and extends for a distance of 210 feet into the harbor, to the Port Warden's line. This condition involved the construction of a permanent protection around this outer portion, consisting of a double row of sheet piling, the space between the rows being filled with earth. The outer end of this protection formed the temporary coffer dam. At the outer edge of the proposed abutments for protecting the entrance of the dock, and also at the inner edge of the same, a line of sheet piling was driven across the slip uniting the side protections and the outer protections; the coffer-dam and these transverse bulkheads were braced and trussed as the work of pumping out progressed, so as to prevent any chance of the bulkheads yielding to the outside pressure. This system of bracing and the constant watchfulness of those in charge have prevented the occurrence of any accidents, and the leakage of water has been of so small an amount as to cause very little delay to the work, especially when it is remembered that the bottom of the excavation was 36 feet below low water.

The entrance aprons and abutments are built of Portland cement concrete, faced with granite masonry. The southerly abutment will contain the pump wells and the tunnel connecting same with the main part of the dock, and will support the pumping station and part of the boiler house. All of this work is of very massive construction to protect the entrance of the

dock from any danger of injury from waves or ice, or from any tendency toward movement under pressure.

The main part or basin of the dock is constructed of timber and piling. The bottom of the dock is supported by thirteen longitudinal rows of piles, the two outer rows and the five rows under the keel blocks having the piles spaced 4 feet on centers and the other rows 8 feet. Upon each row of piles is placed a 12 by 12-inch Georgia pine cap, drift-bolted to the pile, and upon these caps are placed the transverse timbers. These are 16 by 18-inch Oregon fir, 70 feet long, placed every 8 feet, with an intermediate timber 14 feet long. These timbers are securely drift-bolted to each longitudinal cap, and the space between the timbers is filled with earth, well rammed and packed, to the under side of the floor planks. The latter are 4 inches thick, spiked to bearing pieces, which are supported upon the caps and spiked to the transverse timbers. Each slope is supported by five rows of piles, capped with 12 by 12-inch longitudinal timbers, upon which are placed the slope timbers, which are spaced 4 feet on centers, and are alternately 12 by 14-inch and 8 by 14-inch Georgia pine. All these timbers are securely bolted and framed together, and the caps are drift-bolted to the piles. The lower ends of the 12 by 14-inch slope timbers are framed into the tops of the 16 by 18-inch transverse timbers, and the 8 by 14-inch timbers are framed into a 12 by 14-inch filler, which rests on the outer longitudinal cap of the floor piling and is framed into the sides of the 16 by 18-inch transverse timbers. The slope piles are further braced by 12 by 12-inch timbers, extending from the outer ends of the transverse timbers to 6 by 12-inch waling pieces bolted to each row of piles, as shown in the cross-section. The slope timbers are sheeted with 1-inch white pine boards and upon these are placed the altars. Behind the boards and between the slope timbers and piling, earth is filled in and packed solid.

At the easterly end of the dock, on its north side, concrete is to be used instead of earth filling, because the distance from the dock to the outer bulkhead is so small at this point that it was deemed safer to provide extra protection there.

There will be two longitudinal drains, one at each side of the dock, and the floor is laid so as to shed water from the center of dock to the sides, which arrangement will keep the space under the keel blocks always dry when work is being done.

The side drains terminate at the inner apron and discharge into a cross drain, which connects with the tunnel leading to the pumps. The pumps are set on the concrete floor of the power house, at an elevation of 10 feet above the floor of the dock. The suction pipes extend down to about 4 feet below the level of the floor of the dock, into the water chamber. There are three pumps, each having a 36-inch discharge, and one drainage pump having a 14-inch discharge. The three main pumps are calculated to empty the dock in one hour and thirty minutes, and the drainage pump to overcome any leakage which may occur while the dock is in use. Steam will be furnished by three boilers of the water-tube type, operating under a forced draft, and one auxiliary vertical tubular boiler. The latter will be used to furnish steam for operating the drainage pump, and for the engine which drives the draft fan, also for the pump used in emptying the caisson gate. The power house will be of brick, with a slate roof and steel trusses.

The principal dimensions of the dock are as follows:

	Feet.
Length from head of dock to outside of apron	625
Width at bottom of dock	60
top of keel blocks	67
dock	125
of entrance at bottom	60
entrance at top	80
Depth of water on inner sill at low tide	22½
high tide	25
Height of coping above low water	6½
floor of dock	32½

The steel gate consists of a caisson, giving a clear opening of 60 feet at the sills and 80 feet at the top of dock. It has six 36-inch gate valves for filling the dock, and four 6-inch valves for use in filling the gate, and is provided with a pump for emptying it.—"Engineering Record."

NEW DOCK AT NEWPORT NEWS.

The new dock, known as No. 2, has been completed by the Newport News Shipbuilding and Dry Dock Company, and will be ready for use as soon as the dredging at the entrance is completed, when the *Illinois* will be docked in it. Three light-draught vessels, having a combined length of 686.5 feet, were placed in it on the 11th of May. The dimensions of this dock and of the other large one, No. 1, at Newport News are

	No. 1.	No. 2.
Extreme length, feet	638.6	860.5
Length on bottom, feet	573	804
Width on top, feet	130	162
bottom, feet	49	80
Width of entrance at top, feet	96.25	114
bottom, feet	50	84
Depth of water over sill at mean high water, feet	24.5	30
Height of sill above bottom of dock, feet	4.5	1.7

NEW DOCKS AT GIBRALTAR.

The docks will be three in number, the largest, divisible into two, will be 850 feet long, the second 550, and the third 450; with a width of 120 feet in each case, and a depth of 35 feet on the sill at low water. The necessary space for them has been found by cutting off 100 yards of the parade ground by the south mole and banking out the sea. As yet only a portion, about a quarter of the largest dock, where the parade ground formerly was, has been excavated, but the concrete backing for the masonry is already in its place; the excavation of the smallest dock, only commenced six months ago, is already down to the lowest level, but the intermediate dock and the outer portion of the large dock cannot be commenced until the dam cutting off the sea from the intended outer extremity of the docks is completed; this will take another six months.

On the outside of the docks along the foot of the old water-line of the fortification wall a space of foreshore about 500 yards by 150 yards has already been nearly filled in, and on this strongly built sheds for machine shops and repairing establishments have been commenced. Torpedo-boat slips and boat

cambers, in continuation of this filled-in shore extending to the ragged staff landing-place, are rapidly approaching completion. —"Jour. R. U. S. Inst."

DOCK AT VLADIVOSTOCK.

The Russian Government intends to build a fine dock at Vladivostock, at the mouth of the Amur river, capable of taking the largest ships afloat, the length being stated at 700 feet. In addition to the building of this fine drydock, the Russian authorities propose to erect at the same place ample shops and foundries. Large additions to the gun-making plant of the various dockyards are in contemplation, and it is also directed that the manufacture of smokeless powder and other explosives shall receive the attention their importance deserves.—"Engineering."

THE SHEATHING OF WARSHIPS.

Under this head, a writer in "The Naval and Military Record," after questioning the propriety of sheathing the British Royal yacht, proceeds as follows:

To sheath a ship with copper for its anti-fouling properties alone is not only not worth the initial outlay, but really results in a great waste of money for the extra coal burnt, and also a great loss in efficiency. On stations where there are docks, it is the custom for sheathed ships to be docked once a year. At the end of the year, however, the bottom of such a ship will be found to be in a worse state than the bottom of an unsheathed ship which is docked every six months, in spite of the anti-fouling properties of copper. Where there is only a little weed on the latter ship, the former will be found covered with minute shells of animal organisms and embryo barnacles. Consult the log of the sheathed ship and the engine room register, and compare the vessel's speed at the beginning and the end of the year, and the result is startling. Again compare these results with the performances of a sister vessel which (being unsheathed) is docked every six months, and the result is still more startling.

The anti-fouling qualities of copper presuppose that it is origi-

nally clean and smooth on leaving dock. This may be true on first leaving the dockyard; but unfortunately it is not always the case during the periodical dockings of a ship's commission. We have reason to believe that the Admiralty are beginning to doubt, or are not satisfied with, the superior anti-fouling qualities of copper, because at the present time, and for the past two or three years, they have been experimenting with a composition for coating copper-bottomed ships. Why should it be necessary to go to the expense of coating sheathed ships with anti-fouling composition if copper is really so effective as it is believed? As a matter of fact, we are of opinion that the necessity for coating sheathed ships does not arise from a mistaken idea of the merits of copper, but the reason may probably be traced to the cleaning of ship's bottoms when in commission. The usual plan is to scrub down as the water is pumped out of the dock, and this is probably good enough for a six months' docking of unsheathed ships, when there is little more than weed upon the ship. The scrubbing is done by the ship's crew, and when, later on, the dockyard painters come along to put the composition on, they remove any roughness that may be left before applying it. With a sheathed ship, however, that is not to be painted, the scrubbing as the water is pumped out, as a general rule, has to be sufficient. As there is no composition to be applied, the immediate necessity for making the ship's bottom absolutely smooth is probably not taken into account, and the consequence is that a rough surface is formed by myriads of minute shells, which remain as a nucleus for future growth. Cleaning a ship's bottom ought not to be treated as an evolution to be performed as quickly as possible, but the chances are that the work being altogether outside the commanding officer's usual routine, the time for cleaning the ship's bottom is cut down to the shortest possible limits. This is shown by the following illustration:

Two or three years ago, two sister ships, both sheathed, were docked at the same time side by side. Both had the usual scrub down as the water was being pumped out of the dock, the operation being apparently completed at the same time. The dockyard officials, however, thought that one of the ships on

docking had a much larger growth than she ought to have had since the previous docking. The consequence was that they applied for and received permission to try the effect of a special coating of anti-fouling composition for copper-bottomed ships. In order to watch the effect properly, only one side of the ship was to be coated; the other side was to be left bare. When the painters arrived to apply the composition, they found that it was absolutely useless to attempt to apply the paint to the so-called clean bottom, and a squad of men were specially applied for days in scraping off the minute shells that still adhered after the ship had been scrubbed down. This having been done, and the paint applied, the other side of the ship had also to be scraped and cleaned with similar care, in order to make a fair comparison. Whether the coated side or bare copper side proved the superior history does not relate, but the same green composition is still being applied to sheathed ships, and it may be presumed that it is still under trial, or its superiority over bare copper has been proved. Shortly after the two ships in question were completed both were sent on a voyage, practically in company, going the same distance, in the same time, and experiencing the same weather. The speed was eleven knots, and both ships started with four boilers alight; but, whereas the ship which had been properly cleaned maintained its speed with perfect ease and comfort in the stokehold, the other ship, after struggling hard to maintain the same speed, eventually had to light another boiler. Comparisons at the end of the trip showed that one ship had averaged eight or nine revolutions more than the other for the same speed, and with an increased coal consumption of ten to twelve tons a day. Comment is superfluous.

This illustration may not form a conclusive argument against the sheathing of ships, but it must be remembered that this was a case of a fair comparison between two ships which were supposed to leave the dock both in the same clean condition. It is not the theoretical value of sheathing that has to be considered, but the result of working under general service conditions. No unsheathed ship would have been allowed to leave dock in the rough state of one of the ships mentioned above, and it must

be remembered that the other would have left in a similar state but for the fact of trying an experimental coating of paint. The case of these two ships is probably not an isolated one, and, if sought for, many more examples could be found where the sheathing of ships has, perhaps indirectly, been the means of keeping the bottoms in a continually foul condition.

THE INFLUENCE OF BILGE KEELS ON THE ROLLING AND THE RESISTANCE OF TORPEDO-BOAT DESTROYERS.

In the "Rivista Marittima," March, 1901, Sig. Giuseppe Rota gives the following information regarding tank experiments, made at Spezia about four years ago, on the model of a destroyer. The particulars of the projected vessel were:

Length between perpendiculars, feet	229
Beam, feet	22.64
Draught, mean, feet	5.05
Displacement, tons	360
Speed, knots	32
I.H.P.	7,300

The bilge keels were 11½ inches deep, and extended about 50 feet in length.

From rolling experiments made in still water, it was found that without bilge keels, the vessel made 19 oscillations in changing from an inclination of 15 degrees to 3 degrees, while she made only 11 when fitted with keels; and that the corresponding number of oscillations in passing from 10 degrees to 3 degrees was 14 without, and 8 with the keels.

The results of towing experiments were:

Speed without keels, knots	32	30	28	26
Loss of speed due to keels, knots	0.380	0.345	0.300	0.240
Loss of speed in percentage of speed without keels	1.19	1.15	1.07	0.92
E.H.P. for vessel without keels	4,365	3,680	3,040	2,450
Increase of E.H.P. for the same speed when fitted with keels	135	110	90	70
Increase of E.H.P. as above, per cent.	3.1	3	2.9	2.8

[Experiments of a similar nature are now being carried out by the British Admiralty, on the torpedo-boat destroyer *Star*.—ED.]

ROYALTIES PAID FOR BELLEVILLE BOILERS.

Up to the date of the interim report of the Boiler Committee, the British Government had paid in royalties for Belleville boilers an amount that is conservatively estimated at 200,000 pounds sterling. A portion of this was made up as follows:

	£	£
On six battleships, *Canopus* class, at	2,738	= 14,428
On six battleships, *Formidable* class, at	3,008	= 18,048
On six battleships, *Duncan* class, at	3,506	= 21,036
On six cruisers, *Cressy* class, at	4,173	= 25,038
On four cruisers, *Drake* class, at	5,832	= 23,328
On eight cruisers, *Kent* class, at	4,076	= 32,608

EDISON'S WORK IN STORAGE BATTERIES.

Considerable interest has been manifested in the announcement that Edison has been working on a new type of storage battery, but no definite information has been obtainable concerning the same. While the American patents have not yet been issued, an English patent has, however, been recently granted, an abstract of which has just appeared in a German paper. We, therefore, give below a nearly literal translation of this abstract, it being the only information which, up to the present time, is available in this country. We assume that the accumulator described therein is the one—or one among others—on which Mr. Edison is now working, as it answers to the description that it is not a lead accumulator, and that the chemical actions in it are quite different from those in the ordinary storage battery.

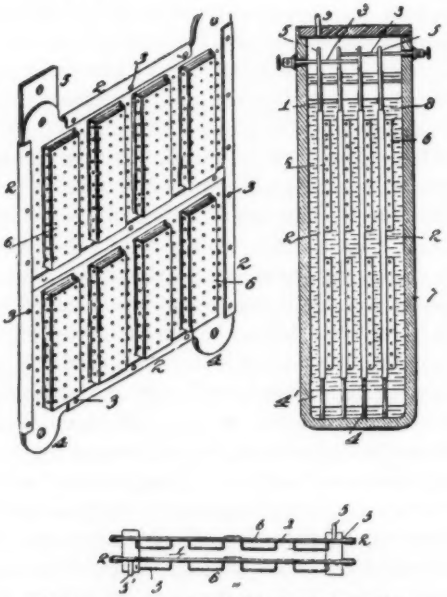
In some respects the German abstract is not very clear, but the general principles of the battery can be understood from the article. It seems to be fundamentally a modification of the familiar copper oxide alkaline accumulator, for which such great claims were made a dozen or more years ago, and one form of which was known in this country as the Waddell-Entz battery. One change seems to consist in having the copper more finely divided, and in the use of cadmium instead of zinc. The battery seems, apparently, to be identical with an accumulator described in a Swedish patent to Schmidt and Junger. There appears to be

a misprint concerning the voltage, which is given as 44, but this is probably a misprint for 0.44, which would be a little more than a fifth of the voltage of the ordinary accumulator. This voltage corresponds approximately to that required by theory. If this is correct, it would, therefore, have to have five times the ampère-hour capacity per pound of cell to be the equivalent of the lead accumulator as to weight. Mr. Edison is understood to have said that he cuts the weight of the cell in two for equivalent work. Judging from the extract from the patent, great care is necessary to have the copper extremely finely divided, or otherwise it is claimed the copper will dissolve.

The abstract, of which the following is a translation, is from the "Centralblatt für Accumulatoren und Elementenkunde." The translation is as follows: The present accumulators are too heavy, because much solution is required. In this new storage battery the electrolyte remains unchanged, so that only a small quantity of it is required. As depolarizer, the lower oxide of copper is used; that is, the red oxide. In the older cells of this general type (referring presumably to the alkaline copper accumulator) soluble copper salt is said to be formed, which transfers copper to the zinc and thus produces rapid deterioration by local action. Efforts were made to prevent the circulation of this salt by surrounding the positive electrode with a porous material, but these experiments were unsuccessful because this material did not prevent the circulation entirely, and was destroyed gradually by the strong alkali; moreover, much liquid was required and the resistance of the cell was greatly increased. Edison has found that very finely divided copper forms copper oxide free from water and insoluble in alkaline lyes, whereas with the smallest particle of solid copper present, or upon the pressing together of the finely divided copper, soluble hydroxide of copper is formed. Finely divided copper is artificially prepared, preferably by the reduction of the carbonate with hydrogen. As negative electrode, finely divided cadmium is used. This and the copper are in a tank of nickel or other metal, such as nickel-plated iron.

Figure 1 gives a perspective view of a plate, Figure 2 a horizontal cross-section of a pair of plates, and Figure 3 a vertical

cross-section of a cell with two pairs of plates. The plate marked 1 is made of relatively thin sheet nickel. The lower parts of the plates are connected by insulating rods, 4, passed through the holes, 4. The pins, 5, in the holes, 5, in the upper parts of the plates are used for the electrical connection. On one side of the plates there are reservoirs or "pockets," marked 6, for the electrode metals. These pockets are best made of perforated nickel sheets or nickel-plated sheets. The best method of cleaning the



FIGS. 1, 2 AND 3.—EDISON'S STORAGE BATTERY

plates is to heat them in a closed compartment to a red heat, and then reduce the oxide by hydrogen. Cadmium in very finely divided, fibrous and very pure condition, is obtained by electrolysis of a weak solution of cadmium sulphate between a thin platinum wire as cathode and a cadmium sheet as anode, using a strong current. The deposit of cadmium is removed from the

cathode from time to time, and freed of the sulphate by washing with water. It is then filled into the "pockets."

Finely divided copper is obtained by the reduction of fine carbonate with hydrogen. The temperature must be kept as low as the completeness of the reduction allows, as otherwise the density of the copper is increased too much. The finely divided copper thus obtained is poured under slight pressure into thin blocks which fit the "pockets" accurately. To avoid an increase of the density of the copper in parts, the molds must not scratch or otherwise injure the plates. The plates are then heated in a closed compartment for 6 or 7 hours, to not more than 260 degrees (probably centigrade), until the copper is changed into the black cupric oxide. At higher temperatures the density is increased too much. The cupric oxide blocks are next reduced to metal electrolytically, and are then changed into the red cuprous oxide by charging. It would be possible to fill the finely divided copper first obtained directly into the pockets; but as it is not fibrous like the cadmium, the connection between the particles is not close enough, so that it is not as good for the purpose as when treated in the way just described.

After the pockets have been filled and the plates of equal sign have been connected together, they are placed in a case, 7, which contains as electrolyte a 10 per cent. solution of pure hydroxide of sodium. During the charging of the cell, cuprous oxide is formed and water is decomposed. During the discharge, cadmium oxide is formed and water is regenerated. As only a very small amount of liquid is required, it is sufficient to place thin sheets of asbestos or another light, powerful material which is not attacked by alkalies, between the plates and to moisten with the electrolyte. The internal resistance is very small. The materials are not attacked, and there is no local action between the cadmium and the nickel. The case, 7, may be made of nickel or other metal, for instance iron, the interior of which is nickel plated. The case may be sealed for liquids, the opening, 9, being required only for the gases which are formed when the cell is overcharged.

It may be added that not only has Mr. Edison stated that he

would reduce the weight of the modern storage battery by one-half, but that he would reduce the depreciation to a tenth—to virtually nothing.—"Electrical World."

EXPERIENCE WITH DESTROYERS.

A naval correspondent of the "Naval and Military Record" gives the following account of the trouble that the Devonport flotilla of British destroyers experienced during a recent cruise:

The instructional destroyer flotilla which returned to Devonport to refit and give Easter leave had another eventful cruise. Of the eight boats which started for the cruise only the *Leven*, *Bat*, *Locust* and *Fairy* returned at the prearranged time. The *Osprey* and *Leopard* had been hors de combat for some days, whilst the *Wolf* was delayed until late on Wednesday evening, having been detailed as escort for the *Seal*, which had developed serious hull defects.

The question of the straining of the hulls of the destroyers at this port promises to become a big one, no fewer than five boats—*Panther*, *Thrasher*, *Seal*, *Wolf* and *Locust*—being affected. The fact of the hulls of these vessels being weak had been known for some time, and orders had been given for them to be paid off, one at a time, to have their deck plating amidships strengthened. In accordance with this the *Panther* was paid off at Christmas, and is now practically completed, but events have marched far too quickly for dilatory Admiralty and Dockyard methods. In January the flotilla was caught in a heavy gale, on passage from Queenstown to Devonport. A few days after starting the next trip the deck of the *Thrasher* showed signs of breaking up, and, it being considered unsafe to continue running any longer, the vessel returned to Devonport, and has since been paid off into the Dockyard Reserve for repairs. After this warning, and knowing the boats were structurally weak, it might reasonably have been expected that a thorough examination of the other boats would have been made, but this apparently was not done, and the flotilla once more left the port for an extended cruise.

Returning from Milford Haven on Tuesday week, heavy

weather was again experienced, which played such havoc with the *Seal* that she had to go to St. Ives Bay for shelter. The deck plating, which had cracked in the other two boats, had also opened in the *Seal*, but to a much greater extent, whilst the sheer strake plating of the vessel's side had cracked and opened out quite half an inch, thus showing the folly of delaying "the stitch in time." The cracking of the side plating naturally follows from the cracking of the deck, and is due to the severe hogging and sagging strains in vessels which are 210 feet long, 21 feet beam, and whose plates only average an eighth of an inch in thickness. These strains are probably more severe in vessels of the *Seal* type, in which one-half the boilers are forward, the other half aft, with the engine room between each pair. There can be not the slightest doubt that if the weather had continued very bad, the vessel would have broken in two and gone to the bottom. Fortunately, whilst in St. Ives Bay, rigging up ties and temporary repairs, the southerly gale died away, and the *Seal*, escorted by the *Wolf*, managed to get round the Land's End before the northern gale, which followed the next day, began to blow. The *Seal* will have to be paid off for repairs, and there is no doubt that the other boats of the same type should be stiffened amidships before being sent for another cruise.

The attempt at running the instructional destroyers away from the port for three weeks at a time, and returning to lie up for one week, has not been very successful. Never during any of the three cruises have the eight boats cruised in company, and at the conclusion of each trip one or more boats have had to pay off. At the present rate of consumption, the reserve supply of boats will not be sufficient to keep the flotilla as a squadron in being at this port. The same difficulty is being experienced at the other ports in keeping the flotillas' numbers up to the establishment of eight. Another illustration of the flimsy nature of the construction of these vessels is shown in the *Osprey*. She was caught by the tide in Portsmouth harbor and driven against a buoy, which struck her about the engine-room bulkhead, and has crumpled the bulkhead and plating like paper. It is fortunate

that nothing more serious resulted than a hole in the vessel's side, but as it is the *Osprey* will have to pay off, as it will take at least two months to effect repairs.

For vessels of this type to be knocking about in the Channel and Irish Sea in weather which causes most other vessels to look for shelter, seems to be the height of absurdity. Nothing is gained by it, no evolution can be carried out, and nothing can be done except steam at a very slow speed and hold on as well as possible. That the boats are perfectly safe and seaworthy everyone who has been in one in bad weather admits; that is, if—and here comes the point—if they do not strain themselves. But that is just what does happen.

Another report says: Since the Devonport flotilla of torpedo-boat destroyers commenced the new system of cruising, viz: three weeks at a time, each trip has been accompanied by mishaps and breakdowns, but never has a flotilla returned to port with such a disastrous record as did the Devonport flotilla last week. The most serious case is that of the *Seal*, which has broken her back, and it is feared she will not again be fit for service—a most unfortunate ending for a comparatively new vessel, which has cost the country about £75,000. She was simply struck by an enormous wave last Tuesday afternoon, when in the Bristol Channel, on her way from Birkenhead to Devonport. The shock was terrific, and those below deck at first thought that she had rushed at full speed into a large vessel or other obstruction. Those on deck, however, feared what had happened, and their fears were realized when they discovered that the upper deck was cracked across over the foremost bunker sufficient to let daylight into the stokehold, and that the side plates were split down to a depth of eighteen inches. Assistance was at once signalled for, and in response the second division of the flotilla was instructed to escort the *Seal* into St. Ives. Here a temporary repair was effected, and, waiting for a break in the continuous bad weather, the *Seal*, under convoy of the *Wolf*, made her way to Plymouth.

The other seven vessels of the flotilla sustained damage or developed defects more or less serious during their absence.

The *Osprey* smashed her bow in by colliding with a coalhulk at Portsmouth. The *Leopard* strained her plating so severely that some of the plates have to be renewed, besides which her port engine gave out off Plymouth, and necessitated her return to Devonport for repairs. The *Bat* and *Wolf* both had trouble with leaky condensers, whilst the *Locust* could not get sufficient power from her engines to enable her to keep up the required pace with the fleet.

THE COSGRAVE PROCESS OF MAKING COMPOUND INGOTS.

Some truth, and much speculation, has been written with regard to the Cosgrave process for producing compound ingots. The manufacture of armor plate has always been in view, but it is only incidental to the tonnage expected from other industrial branches, such as vault steel, gun steel, rolls and agricultural steel. The process is not a complicated one. A core made of such material as will retain the greatest amount of heat, and of any desired thickness, is placed in a mold, fitting it perfectly. A bottom casting of either low or high-carbon steel is made, and when in from fifteen to twenty minutes this casting is set, after being cast, the metal has cooled where it comes in contact with the mold. At the plane of the core, however, it is still at a white heat. Then, without exposing the surface in contact with the core to the atmosphere, in order to prevent oxidization as far as possible, the core is gradually withdrawn. It is followed in its withdrawal by a second bottom casting of low or high-carbon steel. As a result it will be found that the second casting remelts the surface of the first, producing much more than a weld, a certain amalgamation rather of the two castings. The product is a solid ingot showing a graduation of carbon from one side to the other. If desired, an ingot may be made showing a graduation of carbon from the center to the surface or side of the ingot. Armor plate can be thus produced, giving any uniform depth of high-carbon steel required.

The first large plate made by this process will be tested shortly. As it is merely experimental, the gentlemen connected with the invention do not expect that it will reach the perfection

subsequent experiments will show. Armor plate can be made for a less price, but at no such figure as has been stated. It is believed that as a result of future experiments plates will be made more rapidly and at less cost, and they will present a hardened surface of any depth. As the result, lighter plates can be used showing a ballistic test better than those being furnished now. The invention does not claim to make a new quality of steel, but it is a process for improving the various present methods.

The plate to be tested is made from the first large ingot ever cast by this process and could not be expected to do more than demonstrate the practicability of the invention. The future will demonstrate the quality of the steel to be used and the necessary depth of high-carbon steel required.—"Iron Age."

A COALING RECORD.

The five battleships constituting the Portsmouth division of the Channel Squadron, before leaving on their late cruise, completed coaling under the new conditions that have been introduced. As the whole of the ships were practically without coal, it was considered desirable to ascertain how rapidly, with the full use of all available appliances, a war ship could be stored, and it has been clearly demonstrated that in the winter any ship demanding anything up to 1,500 tons, or even more, can be supplied during one day's daylight. To effect this three cranes were kept at work on the shore side, and on the water side were two vessels with two Temperley transporters in each. The question, therefore, arose whether the crew could stow the coal as rapidly as it could be shipped. It was further determined to give, as far as possible, each ship the same chance; but this condition could not be fully observed, for, while four of the vessels coaled in daylight, the *Prince George* had three hours of artificial light—namely, from 5.30 to 8.30 P. M. In each case, however, every detail of the operation was carried out by the ship's companies, the only outside assistance being rendered by the dockyard men who worked the winches on shore. The work, even to bringing

the lighters alongside and the running of the coal to the cranes, was performed entirely by the crews. So keen was the competition that not only lieutenants, but chaplains, surgeons and paymasters threw themselves into the work and wheeled their loads with the energy and rapidity of trained stokers. The following is a return of the operations on the five ships:

Ship.	Date.	Tons shipped.	Working hours.	Average tons per hour.
Hannibal	Jan. 14	943	5 h. 45 m.	170
Prince George	Jan. 25	1,220	6 h. 30 m.	187.7
Resolution	Jan. 28	1,215	7 h. 10 m.	169.5
Majestic	Feb. 4	1,230	5 h. 50 m.	200.3
Mars	Feb. 6	1,070	5 h. 15 m.	203.8

Up to 4 o'clock in the afternoon, or about an hour before coaling ceased, the *Mars* had averaged 218 tons an hour, but at this point the fuel accumulated on deck, the men below being unable to trim it as rapidly as it was sent down; and though this broke down her average, she for the present holds the record so far as the Portsmouth division of the Channel Squadron is concerned. It should be mentioned that the competition was instituted without any advice or recommendation from the Admiralty, but in order that Commander Heathcote, who has relieved the dockyard store officer of the responsibility, might obtain information for his guidance in the event of an emergency arising.—"Jour. R. U. S. Inst."

A NEW SWEDISH TORPEDO.

The Swedish Government has assigned to Major W. T. Unge a grant out of the revenue of the State in order to make trials of the self-moving torpedoes invented by him, intended to carry large charges of explosives through the air for a considerable distance. The primary object of these experiments is to ascertain the manner of using, the extent of the range, the accuracy of aim attainable and the destructive effect of the explosion.

The trials will be made in the presence of one or more artillery officers, who will be appointed to this duty by the Grand Master

of the Ordnance and the Inspector of Artillery, with the object of gaining a more accurate knowledge of the invention.

Major Unge's torpedo (patented under the name of the "Flying Torpedo"), on which several years' work has been expended, and with which a great number of shooting trials have been made for the last few years in the shooting field of the Swedish Royal Artillery at Marma, is externally like an elongated shell. It is propelled through the air entirely by a succession of impulses produced within the torpedo itself. These impulses are obtained by the ignition of a comparatively slow-burning gas-producing composition enclosed in the torpedo. The pressure of the gas thus produced, the expansion of which is continuously increased after the original ignition, impels the torpedo forward by the reaction of the pressure of the gas, which is allowed to escape freely through the passages of a turbine placed at the bottom of the torpedo. Once put in motion the speed of the torpedo increases in proportion to the increase of pressure of the gas generated within it. The torpedo is put in motion without any violent shock and moves at first at slow speed; it can, therefore, without danger, be loaded with any explosive agent no matter how sensitive to shocks. In consequence of its self-moving ability it does not need a great mass in order to overcome the resistance of the air. It can, on the other hand, carry a great quantity of explosive. This explosive charge comes into activity as soon as the torpedo strikes the object aimed at.

The object of the turbine is to enable the torpedo to rotate about its longitudinal axis, and so continue in the desired direction. The explosion of the charge is effected by the action of a special apparatus which comes into play automatically by centrifugal force as soon as the torpedo has acquired a certain rapidity of rotation. In order to obtain the desired direction and elevation, the torpedo is fired out of a specially constructed gun. Since the torpedo, as already mentioned, is propelled by its own interior power, it does not require, as other projectiles do, any firing or impelling charge, whence it follows that the firing of it is attended neither by loud report, perceptible recoil,

nor any considerable pressure. A torpedo gun of fairly large caliber can, in consequence of this, be made light and simple, becoming thereby particularly easy to transport and comparatively cheap to construct.

As the angle of elevation may be very great, this new weapon might chiefly be used where the so-called vertical fire is necessary. Concerning this use of it the Swedish Artillery Department states in its report on the invention that the weapon in question may prove of great military value, particularly in attacking fortified places and aiming at objects placed behind defensive works—a question which at present occupies a very important place among military problems.

As the torpedo gun, which, in certain cases, may consist of merely a simple pipe, can be easily transported by land or by water, the invention may be of great use where the nature of the country or any other circumstances make the transportation or the use of ordinary artillery impossible. It may also be of great value in coast defense.

The torpedoes tested up to the present contained 2.5 to 3 kilogrammes of explosive charge, and had a range of 4,000 to 5,000 meters. A gun to discharge torpedoes that would carry as much as 20 to 30 kilogrammes of explosive charge can be made so light that it can be transported over very difficult country. To operate against fortresses or ships, it would not be difficult to make flying torpedoes which would carry explosive charges of 150 to 200 kilogrammes; and it is claimed that the larger torpedoes would have a range of 8,000 to 10,000 meters.

THE UNITED STATES SHIPBUILDING COMPANY.

A consolidation has recently been effected by which the following well-known shipbuilding companies—

The Newport News Shipbuilding and Drydock Company,

The Union Iron Works of San Francisco, Cal.,

The New London Shipbuilding Company of New London, Conn.,

The Crescent Shipyard of Elizabethport, N. J.,

The Bath Iron Works and the Bath Windlass Company of Bath, Me., and

The Canda Manufacturing Company of Carteret, N. J.,

have been combined under the title of the United States Shipbuilding Company. The company will be incorporated under the laws of the State of New Jersey, with a capital stock of $65,000,000.

The Board of Directors will consist of Henry T. Scott, president of the Union Iron Works; Lewis Nixon, Crescent Shipyard; Charles J. Canda, president of the Canda Manufacturing Company; John S. Hyde, president of the Hyde Windlass Company; E. W. Hyde, president of the Bath Iron Works, Limited; E. H. Harriman, chairman of board, Union Pacific Railroad Company; H. E. Huntington, first vice-president of the Southern Pacific Company; Irving M. Scott, vice-president and general manager of the Union Iron Works; C. B. Orcutt, president of the Newport News Shipbuilding and Drydock Company; Edwin Hawley, president of the Minneapolis and St. Louis Railway Company, and James Stillman, president of the National City Bank, New York.

There is to be $32,500,000 7 per cent. non-cumulative preferred stock, and $32,500,000 common stock, all of which will be issued and delivered to the Mercantile Trust Company as depository as soon as the company is organized. For the purpose of carrying out the above plan, H. W. Poor & Co. will receive subscriptions for $20,000,000 preferred stock at par, with an equal amount of common stock. The aggregate of the orders now placed with the constituent companies is for more than $63,000,000 worth of work, which will require an average of eighteen months for completion, and upon which the estimated profit will be over $7,000,000. With that as a basis, the organizers of the new trust estimate that the future annual net earnings will average about $6,000,000, or enough for 7 per cent. dividends on the preferred and 6 per cent. on the common stock, and a substantial surplus.

It is said that the company intend building the largest drydock in existence in New York harbor. The location announced

is on the New Jersey shore of the Staten Island Sound or Arthur Kill.

FLEET AUXILIARIES.

In the statement of the First Lord of the British Admiralty explanatory of the naval estimates, the following information is given regarding "fleet auxiliaries":

"The provision of fleet auxiliaries is under the careful consideration of the Board. Three colliers are now working with the fleet; a repairing and distilling ship has been purchased and is now being fitted up; provision is made in the estimates for another distilling ship and for a depot ship, while it is expected that the *Maine* will, with the kind assistance of the committee of American ladies and the owner, be secured for service as a hospital ship in the Mediterranean during the ensuing summer."

In pursuance of this the collier *Khaki* was bought for service with the Channel squadron, and the *Nubian* as a coal depot vessel at the Cape of Good Hope. Another collier, the *Hampstead*, specially built for the coal trade, has been purchased and will be converted into a distilling ship. She has a capacity for 2,000 tons of coal and a speed of 10½ knots.

The *Assistance*, a new vessel, has been purchased for use as a repair ship, and is now being fitted out with the necessary tools and equipment. She is 436 feet long, 53 feet beam, 20 feet mean load draught, and of 9,600 tons displacement. Her engines are of 4,200 I.H.P., the cylinders being 32, 53 and 88 inches in diameter by 54 inches stroke. The boilers are four in number, 16 feet diameter and 12 feet long, are designed for a working pressure of 180 pounds, and fitted with forced draft on the Howden system.

The speed of this vessel is 12 knots with 3,000 I.H.P. under natural draft, and 13 knots under forced draft.

DANGER FROM OIL FUEL.

Early in the month of April, the German battleship *Kaiser Friedrich III* ran aground, injuring four compartments of her

double bottom, in which "mazut" (tar oil) was stored for use as fuel in conjunction with coal. The inner bottom plating of one of these compartments was ruptured, the oil escaped into the fire room and ignited, driving the men out, and for a time the conditions were so serious that it was thought the ship would have to be abandoned. Finally, by flooding the compartments affected, the fire was extinguished, and she was towed into port. It was at first thought that her boilers were seriously injured, but it is now reported that they are not, and that the damage by fire is confined principally to the center engine, and to the bulkheads, some of which are badly warped. —"Le Yacht."

SHIPS.

UNITED STATES.

Milwaukee.—One of the three protected cruisers referred to on page 238 of the last number of the JOURNAL, for which bids were opened February 1, 1901.

The Bath Iron Works, to whom this vessel was offered on the same terms as were accepted by Messrs. Neafie & Levy for one of the class, having declined the Department's offer, she was again advertised, and bids for her construction opened on the 4th of April. Three bids were received, two from the William Cramp and Sons' Ship and Engine Building Company and one from the Union Iron Works.

The first proposal of the Cramp Company was to build a vessel of 9,700 tons trial displacement, having a speed of 23 knots, for the sum of $2,740,000, provided the Secretary of the Navy would agree to ask Congress for an additional appropriation sufficient to make the cost of construction $3,000,000. Their second proposal, which was for consideration only in case the first one was not accepted, was to build a vessel of 8,800 tons trial displacement and 22 knots speed for $2,740,000. Neither of these proposals were accepted, but the contract was awarded to the Union Iron Works on their bid of $2,825,000, that firm agreeing to build her in accordance with the Department's plans and specifications, modified in accordance with the terms agreed upon for the *St. Louis*, the vessel to be built by Neafie & Levy, and noted on pages 238 and 239 of the last number of the JOURNAL.

The second of these cruisers, to be named *Charleston*, will be built by the Newport News Shipbuilding and Dry Dock Company, that firm having accepted the terms offered by the Department.

The chief characteristics of these vessels are:

Length on water line, feet	424
Breadth at water line, feet	66
Draught, mean, trial, feet	22.5
Displacement, tons	9,700
Coal at above displacement, tons	650
Bunker capacity, tons	1,500
I.H.P.	21,000
Speed, knots	22

Illinois.—On the 12th of March this vessel was taken outside the capes of the Chesapeake for a preliminary trial by the builders, during which she was run under forced draft for one and a half hours. Though no accurate measurement of the speed was taken, it was estimated to have been 15.5 knots, which was considered satisfactory, as the ship had not been docked for ten months. During this part of the run the engine made 106 revolutions per minute, and no difficulty was experienced in maintaining 175 pounds of steam with $\frac{3}{4}$-inch air pressure. The official trial will take place on the 12th of June.

Ohio.—The launch of this battleship took place on the 18th of May at the Union Iron Works, San Francisco, Cal. The general features of her design have been given in Volumes X and XI of the JOURNAL.

Barney.—On the 15th of May, this torpedo boat, built by the Bath Iron Works from their own design, made a very successful trial, averaging 29.1 knots for two hours. The contract speed was 28 knots.

The trial of the sister boat, *Bagley*, followed on the 16th of May, her average speed being 29.2 knots. The trial of the third boat of the same design, the *Biddle*, will follow shortly.

Bailey.—The official trial of the torpedo boat *Bailey*, built from their own design by the Gas Engine and Power Company and Charles L. Seabury, Morris Heights, New York, took place in Long Island Sound on the 25th of April, the mean speed for the two hours being 30.2 knots. No difficulty whatever was experienced in reaching the contract speed, there being an abundant supply of steam throughout, and the speed at one time reaching 31.12 knots with 418 revolutions of the engines.

The *Bailey* ran her "standardizing" trials several months ago,

but, owing to the intensely cold weather prevailing, her official trial was postponed until danger from ice was over.

Her dimensions are: Length, 205 feet; beam, 19.24 feet; draught, 6 feet; displacement, 235 tons.

Goldsborough.—The standardizing trials of the *Goldsborough*, a torpedo boat built by Messrs. Wolff & Zwicker, Portland, Oregon, from their own designs, were completed about the 10th of March, the mean displacement for the runs being 255 tons. The results were:

Mean revolutions per minute.	Mean speed in knots.
228.7,	20.69
263.3,	24.35
287.6,	26.33
322.6,	29.53
343.7,	30.84

Following these runs, an attempt was made on the 18th of March to run the official trial, the requirements of which are that the boat shall maintain an average speed of 30 knots for two hours. But after running for forty-six minutes, the port low-pressure eccentric rod broke in the jaw at either side of the rod and brought the trial to a close. At the time of the accident the steam pressure was 220 pounds, and the revolutions 310 per minute. The rod was a nickel-steel forging.

Perry.—The preliminary and the standardizing trials of this destroyer, building by the Union Iron Works from the design of the Navy Department, and described on page 818 of Volume X, were carried out in San Francisco Bay between the 25th of February and the 5th of April, and, in consequence of the results being so far below what was anticipated, it has been determined to suspend further trials pending the construction of screws with more surface than those with which she was fitted during these trials. Should she succeed in reaching the contract speed with the new screws, the *Preble*, also building by the Union Iron Works, will be tried with similar ones; but should she fail, a change will be made in the shape of the stern.

As completed, she draws 14 inches more at the stern than was contemplated in the design, and is of about 470 tons displace-

ment instead of 430, this increase being principally in the weights of the hull. Some of the trial weights were removed in order to improve her trim before commencing the standardizing trials.

The results of these trials, made on different days, are:

Speed.	Revolutions.	I.H.P.
17	177.8	947
19.72	212.6	1,792
23.31	269.1	4,005
24.17	287.2	4,866
25.50	308.1	6,040
27.68	333.2	7,470
28.20	338.5	7,752

The contract speed is 29 knots.

As a consequence of these trials, and of runs, in the model tank of the model of the vessel as completed, it is probable that the sterns of the destroyers *Bainbridge*, *Barry* and *Chauncey*, building by Messrs. Neafie & Levy, and of the *Paul Jones*, building by the Union Iron Works and yet unlaunched, will be flattened in order to reduce the resistance which the peculiar shape of the stern appears to offer.

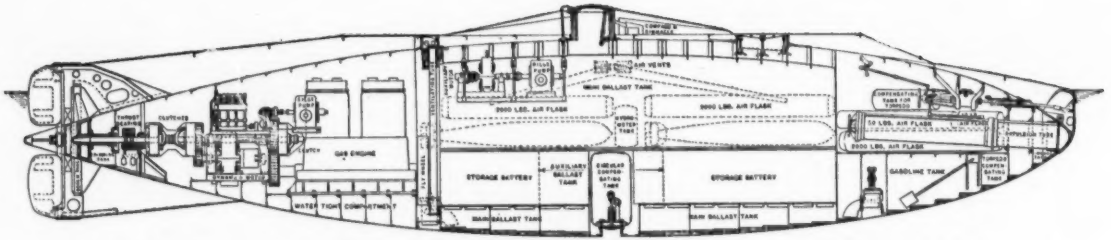
Two other destroyers, the *Dale* and *Decatur*, building by the William R. Trigg Company, have been launched, but as the speed in their case is to be but 28 knots, it is probable that alterations of the stern will not be made until after they have been tried. The *Preble* was launched on the 2d of March.

Shubrick.—This torpedo boat completed her official trial on the 5th of April, having made an average of 26.07 knots for two hours.

The *Thornton*, a sister boat, was tried on the 12th of April, but the trial was suspended on account of a tube in one of her boilers having burst.

A full description of these boats will be given in the next number of the JOURNAL.

Tingey.—There was launched on Monday, March 25, from the yard of the Columbian Iron Works, Baltimore, Md., the torpedo boat *Tingey*. She is one of the group of twelve torpedo boats and sixteen destroyers appropriated for by Congress in



CHIEF CHARACTERISTICS OF THE SUBMARINE BOATS, ADDER, GRAMPUS, MOCCASIN, PIKE, PORPOISE AND SHARK, NOW BUILDING FOR THE U. S. NAVY.

1898. Her length on load-water line is 175 feet; breadth, 17 feet 6 inches; mean draught, 4 feet 8 inches, and displacement at this draught, 165 tons. She is a twin-screw vessel, with vertical triple-expansion engines and Thornycroft boilers of 3,000 horsepower, and her designed speed is 26 knots. Her bunker capacity is 30 tons. Her battery will consist of three 18-inch Whitehead torpedo tubes and three 3-pounder rapid-fire guns. The contract price was $168,000. The vessel was christened by Miss Anna Truxtun Craven, a descendant of Commodore Tingey (for whom the boat was named) and a niece of Assistant Secretary of the Navy Hackett.

Owing to the financial condition of the Columbian Iron Works, the Navy Department declared the contract forfeited, and was about to advertise for bids for completing her; but a new company having been formed in Baltimore to operate the Columbian Iron Works, the Department has decided to entrust the completion of the *Tingey* to this company.

Submarine Boats.—The following are the dimensions of the *Adder*, *Moccasin*, *Porpoise* and *Shark*, building by Lewis Nixon, Elizabeth, N. J., and of the *Grampus* and *Pike*, by the Union Iron Works, San Francisco, Cal.:

Length over all, feet	63.33
Diameter, feet	11.75
Displacement, submerged, tons	120

They are provided with single screws and four-cylinder Otto gasoline engines of 160 I.H.P. (see last number of the JOURNAL), and have also main electric motors of the water-proof type of 70 horsepower. There is capacity in the storage tanks for 850 gallons of gasoline, and the speed, submerged or awash, is estimated at 7 knots. The armament consists of one torpedo-expulsion tube, for which there are provided five 45-centimeter by 11 feet 8 inches Whitehead torpedoes. The conning towers are 21 inches diameter, and are protected with 4 inches of armor. The contract price for the hull and machinery of each of these boats is $170,000. The internal arrangement is shown in the accompanying illustration, which is reproduced from "Marine Engineering."

AUSTRIA.

A new battleship, similar to *Kaiser Karl VI*, is under construction. Her principal characteristics will be:

Length, feet	383.87
Beam, feet	61.68
Draught, mean, feet	21.32
Displacement, tons	7,400
I.H.P.	13,020
Speed, knots	21

The engines will be triple expansion, and the boilers of the Yarrow type.

The main battery will comprise two 9.5-inch in two turrets, one forward and the other aft, and ten 6-inch guns in casemates. Protection will be given by a partial belt extending between the turrets, 8.66 inches thick at the water line, and by a protective deck. There will be 7.87-inch armor on the turrets and 4.92-inch on the casemates.

DENMARK.

Herluf Trolle.—The trials of this armored vessel were recently completed with satisfactory results, her speed under natural draft being 14.6 knots with 3,170 I.H.P., and under forced draft 15.65 knots with 4,399 I.H.P.

Her principal features are:

Length, feet	272.2
Beam, feet	49.2
Draught, feet	16.1
Displacement, tons	3,470

Battery.—Two 9.45-inch, four 6-inch and ten 57-millimeter guns and three submerged torpedo tubes.

ENGLAND.

Russell.—A first-class battleship of the *Duncan* class was launched at the works of the Palmer Shipbuilding and Iron Co., Jarrow-on-Tyne, on the 19th of February. Her keel was laid March 11, 1899, and as an indication of the progress made, it may be said that her launching weight was 6,000 tons.

Her principal characteristics are:

Length between perpendiculars, feet	405
Breadth, extreme, feet	75.5
Draught, mean, feet	26.5
Displacement, tons	14,000
I.H.P.	18,000
Speed, knots	19
Coal at above displacement, tons	900
Bunker capacity, tons	2,000
Weight of hull, tons	9,055

The armor belt is 286 feet long, and extends 5 feet below the load line and 9 feet above it, the total depth being thus 14 feet. At the forward and after end there are the usual armored bulkheads forming the citadel; but instead of the ends of the ship being unprotected, as was the case with battleships some years ago, armor is continued to the ram, being reduced first to 4 inches and then to 2 inches in thickness, the latter increasing in depth, and finishing in a rabbet on the stem from top to bottom, so that the ram is greatly reinforced in strength. Abaft the citadel the shell plating is similarly clothed with a belting of two thicknesses of ½-inch nickel steel. The barbettes, forward and aft, are, as usual, within the citadel; and the armor, beginning at the middle deck and extending through the main to above the upper deck, is in parts 10 inches, and in others 11 inches thick, and has been treated by the Harvey process. The 6-inch guns are all within casemates of 6-inch armor.

As to the protective flats, the main deck, which forms the top of the armored citadel, is 2 inches thick, reduced to 1 inch at the stem. The middle deck is of 1-inch steel, is horizontal in the center, and is there 2 feet 6 inches above the load line, but is sloped down at an angle of about 40 degrees at the sides to 5 feet below the load line, which forms the shelf on which the side armor rests. This protective deck runs in this form from the after to the forward barbettes, of which it is the foundation; it then dips down at the center, gradually losing the angles at each side, and eventually forms the lower deck, still retaining its protective thickness right to the stem casting, to which it is strongly secured. Before and abaft the barbettes the line of

this deck is continued as an ordinary deck. The lower deck is a sloping protective deck of 1 inch thickness forward of the forward barbette, and 2 inches thick aft of the after barbette, protecting the steering gear, etc. With a view to preventing water from finding its way below the protective deck, means are provided for closing the several openings by watertight shutters and covers, while in the case of those which must necessarily remain open in action, cofferdams have been fitted with the same object.

The division of the ship into 320 watertight compartments also adds to the safety of the vessel. There is a double bottom, extending four-fifths of her total length, under the engine and boiler-rooms, magazines and shell-room spaces. The port and starboard engine-rooms are divided by a middle-line watertight bulkhead, extending from the keel to the main deck ten feet above the load-water line. There are three boiler rooms, each being a separate watertight compartment, and containing in all 24 Belleville water-tube boilers. There are longitudinal watertight bulkheads at the sides extending throughout the machinery and boiler spaces, and subdivided by athwartship watertight bulkheads, forming in all 52 coal bunkers, which act as an additional protection to the engines and boilers.

The main armament includes four 50-ton breech-loading guns of 12-inch caliber, with a training of 120 degrees on each side of the middle line. The principal guns in the auxiliary armament are twelve 6-inch quick-firing guns, each placed in a casemate of Harveyed armor 6 inches thick. Four of these are on the upper deck, the two forward ones training over the bow and 30 degrees abaft the beam, and the two after ones training over the stern and 30 degrees forward of the beam. The other eight are fitted on the main deck, and the four forward and aft can be trained through the same arcs as the guns on the upper deck, and the four in the midships can be trained 60 degrees before and abaft the beam. There are also twelve 12-pounders, two in the bows and two in the after quarter on the main deck, six in the waist of the ship on the upper deck, and two on the forward shelter deck, the latter being field and boat guns; eight Maxims on the shelters and bridges, and six 3-pounders, three in each military

fighting top. There are also four submerged 18-inch torpedo tubes, two forward and two aft.

The *Russell* will be lighted throughout by electricity, with an installation of about 900 electric lamps, and will also be equipped with six searchlights of 25,000 candlepower each, the dynamos being under protection.

A departure has been made in connection with the engines, which partake more of the characteristics of the cruiser type than of the design formerly adopted in most battleships. They have been designed by Mr. T. W. Reed, the engineering manager of the Palmer Company. Their principal dimensions and the boiler data are:

Indicated horsepower	18,000
Cylinders, H.P., diameter, inches	33½
I.P., diameter, inches	54½
L.P. (2), diameter, inches	63
Stroke, inches	48
Revolutions per minute	120
Working pressure, engines, pounds	250
boilers, pounds	300
Boilers, Belleville, number	24
Grate surface, square feet	1,375
Heating surface, square feet	43,260
Weight of machinery, tons	1,580

The high-pressure and intermediate cylinders are placed in the middle, and a low-pressure at each end. The crankshaft is in two sections, each section having two double-throw cranks. The body of the shaft and pins are hollow. The high-pressure and intermediate-pressure cylinders have piston valves with packing rings of the restrained type, and the low-pressure cylinders flat slide valves, with efficient relief rings on the back. The valves are all worked by ordinary link motion, connected to a massive weighshaft along the front of the engines. The reversing is by a continuous roundabout worm-and-wheel gear, driven by a double-cylinder engine. Powerful hand-reversing gear is also provided, this and the steam gear being connected by clutches to the wormshaft. All the hand gear is brought to the middle of the starting platform to give ready control with the

minimum number of attendants. The propellers turn inwards, as is usual in large vessels of His Majesty's Navy, and this enables the starting platform to be alongside the middle line fore-and-aft bulkhead. Through this there is a doorway, making supervision of the two sets of engines very convenient.

The bedplates and back standards are of cast steel, the latter being split at the bottom to get direct attachment to the girders of the bedplate. The front columns are turned steel forgings, their bottom ends being directly connected to the six cross girders carrying the bearings. As the cylinders are bolted together in pairs, each pair is thus supported at the back by two cast-steel standards, and at the front by three turned forged-steel columns. The cylinders themselves are, of course, of cast iron, but their pistons and covers are of cast steel. The piston and connecting rods are of substantial proportions, the bearings of the latter having large surfaces. The high and intermediate rods have to transmit each about one-third of the total power on each shaft, and are made considerably larger than those for low pressure, which have each to transmit about one-sixth. The piston rods have large shoes working on the guide plates, bolted to the back columns.

Each low-pressure cylinder has its own condenser and air pump, the latter being driven by levers from the piston rod crosshead. As the two condensers in each engine room are arranged so that both low-pressure cylinders may exhaust into either one or the other alone, as well as into both together, there will be ample opportunity for keeping the tubes thoroughly clean and the condensers otherwise efficient. The air pump discharges the water into large hotwell tanks, from whence it is pumped by a large hotwell pump of the Weir type through grease filters into the feed tanks, to which all the feed-pump suctions are connected. Two large centrifugal pumps, with independent engines, are fitted in each engine room for circulating the water through the condensers.

The shafting is of steel, bored hollow, the stern-tube length being covered with gun-metal sleeves in one length. The pro-

pellers are four bladed, the boss and blade being made of manganese-bronze.

In each engine room there is an unusually large set of distilling plant, the exhaust steam from the various auxiliary engines throughout the vessel being used in this for evaporating from the sea water. There are also in each engine room two large bilge-pumping engines, electric-light machinery, steering engine and a surface condenser for the auxiliary machinery, with its combined air and circulating pump. Although such a large amount of machinery is to be put into a comparatively small engine room, there will be ample room for convenient access to all parts.

The boilers are divided over three separate watertight compartments. There are two groups of eight placed back to back and two of four placed back to a bulkhead. The working pressure is 300 pounds per square inch, to be reduced to 250 pounds at the engines. The boilers are fitted with economizers, through which the feed water passes on its way from the feed pumps to the boilers proper or generators. The upstakes lead into two funnels. The boilers are fitted with automatic feed regulators, and all the usual mountings. The tubes are solid-drawn steel, galvanized, and the junction boxes are of malleable cast iron. In each boiler compartment there are a main and an auxiliary feed pump of the Weir type, and three double-cylinder air-blowing engines for the air jets in the furnaces. Large centrifugal fans are provided for bringing a supply of air down to the stokehold. Steam ash-hoisting engines with friction gearing are also fitted.

The main steam pipes—in fact, all the steam pipes except the small ones—are of steel, and, except the large ones, are all solid drawn. The main and auxiliary steam pipes are carried from the separate boiler compartments to the engine-room bulkhead, where they join up to self-acting stop valves, from which main pipes lead to the separators and to the main and auxiliary engines. There are separate engine rooms provided for the engines that are not accommodated in the engine and boiler rooms, such as air-compressing machinery, refrigerating machinery, hydraulic machinery, electric-lighting machinery, etc.

A very complete workshop is also provided with a number of useful machines, such as lathes, shaping machine, punching and shearing machine, grindstones, &c., all driven by a separate steam engine. In suitable positions on the ship there will also be fitted boat-hoisting machinery and coal hoists.

A comparison of the *Russell* with the three preceding types of battleships follows:

Type	*Majestic.*	*Canopus.*	*Formidable.*	*Russell.*
Number included	Nine	Six	Six	Six
Length between perpendiculars, ft.	390	390	400	405
Breadth, feet and inches	75	74	75	75–6
Draught (mean) feet and inches	27–6	26	26–9	26–6
Weight of hull, tons	10,180	8,545	9,985	9,055
Displacement, tons	14,900	12,950	15,000	14,000
Speed in knots	17.5	18¼	18	19
Indicated horsepower { Natural	10,418	13,500	15,000	18,000
Indicated horsepower { Forced	12,497	.....	.....	.....
Cylinders { High pressure, inches	40	30	31½	33½
Cylinders { Inter. pressure, inches	59	49	51½	54½
Cylinders { Low pressure, inches	88	80	84	63 and 63
Stroke, inches	51	51	51	48
Revolutions	106	108	108	120
Piston speed, feet	901	918	918	960
Working pressure (engines), pounds	155	250	250	250
Boilers	8 S. E. cy.	20 B.	20 B.	24 B.
Heating surface, square feet	25,570	33,793	37,120	43,260
Grate area, square feet	821	1,050	1,170	1,375

The complement of the *Russell* will be 750 all told. The officers and crew are accommodated on the middle and main decks, the admiral and captain having day cabins on the upper deck. The officers' accommodation consists of handsomely-fitted cabins, situated aft, the superior officers being located on the main deck. The admiral's accommodation is at the extreme aft end of the main deck, with access to a handsome stern walk fitted with a light steel canopy. The upper deck extends from stem to stern without a break, and above it are the forward and after shelter decks, on which are placed the conning towers, the former being of 12-inch Harveyed steel, and the latter of 3-inch nickel-steel. These are surmounted by flying bridges, and connected on each side by a fore-and-aft bridge. The boats, of which there are 18, including two 50-foot steam pinnaces, are stowed amidships on skid beams. A strong steel derrick,

worked by hydraulic power and tested to 36 tons lift, is fitted to the mainmast for lifting the boats, and the foremast is also fitted with two steel derricks, each tested to 10 tons, for working the light boats. The fore and main lower masts are built of steel, and fitted with military fighting tops and searchlight platforms, with wood topmasts and upper and lower signaling yards. There are two funnels in a fore-and-aft line between the masts.

—"Engineering."

Bacchante.—A sheathed armored cruiser of the *Cressy* class, was launched from the Clydebank Works of John Brown & Co., on the 21st of February. Her principal dimensions are:

Length between perpendiculars, feet	440
Breadth, extreme, feet	69.5
Draught, mean, feet	26.25
Displacement, tons	12,000
I.H.P.	21,000
Speed, knots	21
Weight of hull, armor and backing, tons	7,840
Coal at normal displacement, tons	800

Battery.—Two 9.2-inch; twelve 6-inch; twelve 12-pounders and five smaller guns.

There is an armor belt extending a distance of 230 feet, beginning 120 feet from the bow and terminating 90 feet from the stern; it is 6 inches thick in the heaviest portion, and tapers to the ends. Its width is 11 feet 6 inches, of which 5 feet is below water. The total weight of armor is 1,100 tons.

The 9.2-inch guns are mounted in barbettes, one forward and one aft, the protection being six inches thick. Of the 6-inch guns, eight are in casemates, four arranged for ahead and four for astern fire; the remaining four are mounted amidships on the main deck.

The engines each have four cylinders, the high-pressure 36, the intermediate 59, and the two low-pressure 63 inches diameter, with a stroke of piston of 48 inches. The revolutions expected at full power are 120. The boilers are 30 in number, of the Belleville type, working under a pressure of 300 pounds, which is reduced to 250 at the engines, and occupy 130 feet in

length of the ship. The heating surface is about 41,500 square feet.

Good Hope.—On the 21st of February, this cruiser, an improved *Powerful*, was launched from the Fairfield yard. When originally laid down she was known as the *Africa*, but this was changed to *Good Hope*, as a compliment to the people of Cape Colony. She differs from the *Powerful* in being unsheathed, in having a heavier battery and better protection, and in being faster. Her chief characteristics are:

Length between perpendiculars, feet	500
Breadth, extreme, feet	71
Draught, mean, feet	26
Displacement, tons	14,000
I.H.P.	30,000
Speed, knots	23
Weight of hull, armor and backing, tons	8,500
Coal at normal displacement, tons	1,250
Bunker capacity, tons	2,500

Battery.—Two 9.2-inch; sixteen 6-inch; fourteen 12-pounders; three 3-pounders; nine Maxims; two 18-inch submerged tubes.

The 9.2-inch guns are in 6-inch armored barbettes, one forward and one aft, and the 6-inch guns in 5-inch casements.

The armored and protected sides extend from the stem for a distance of 400 feet, enclosed aft by an armored bulkhead. The 2-inch armor is of nickel-steel, and extends from the lower deck to the upper deck, affording cover to the men at the 12-pounder guns on the main deck forward. The thicker armor is all of specially hardened steel. There are two armor decks, the lower and main, the main deck being thicker in the way of the citadel, and forming its crown. The lower deck has sloping sides, which meet the bottom of the armor belt below water. Aft of the citadel the lower deck forms the protection over the steering arrangements, and is of 2½-inch steel. In addition, the coal bunkers are so disposed as to give protection to the machinery. There is a conning tower of 12-inch armor, with armored communicating tube to protect the gear for controlling operations throughout the ship. There are two navigating bridges, one

forward and one aft. The ship's complement is 900 officers and men.

The propelling machinery consists of two sets of triple-expansion engines, fitted in two watertight compartments, each set having four inverted cylinders working on four cranks. Each high-pressure cylinder is 43½ inches, each intermediate 71 inches, and each low-pressure 81½ inches diameter, all adapted for a stroke of 48 inches. The high and intermediate-pressure cylinders are each fitted with a piston valve, and each low-pressure cylinder with a triple-ported slide valve with a relieving ring at the back, all the valves being worked by the usual double-eccentric and link-motion gear. Reversing is effected by means of double-cylinder steam engines. The main condensers will be placed at the back of the engines, and are cast brass of oval form. The condensing water will be supplied by four centrifugal pumps, each fitted with an independent engine. There will be two auxiliary condensers, each with the usual pumps.

Steam will be supplied by forty-three Belleville boilers working at a pressure of 300 pounds, which is reduced to 250 pounds at the engines. They will be arranged in four groups, each group fitted in a watertight compartment. Air-pumping engines will be fitted in each boiler room to supply air to the furnaces and combustion chambers. The necessary air for the stokehold ventilation will be supplied by large fans. Fans will also be fitted for the engine room and ship ventilation.

The auxiliary exhaust steam will be arranged to discharge to the auxiliary condensers, the atmosphere and the low-pressure receivers, and for working the evaporators. Feed-water filters will be fitted to prevent any impurities reaching the boilers. The vessel will also be fitted with a complete distilling plant to supply fresh water to the boilers, and for drinking purposes; three sets of engines and dynamos for producing the necessary current for electric lighting and for six searchlights; two double-cylinder direct-acting engines, with the necessary gear for steering purposes; two complete sets of air-compressing engines and pumps, with the necessary air reservoirs and columns for charging torpedoes; and one ice-making machine of the cold-air type, includ-

ing an ice-forming chamber and a pump for circulating water in the air cooler.

Drake.—A cruiser, sister to the *Good Hope*, was launched at Pembroke dockyard on the 5th of March. In general construction and armament she is identical with the *Good Hope*.

Her engines will be built by Messrs. Humphreys & Tennant, and will be balanced on the Yarrow, Schlick and Tweedy system. The cylinders are 43½ inches diameter for the H.P., 71 for the I.P. and 81½ for each of the L.P., the stroke being 48 inches.

Each set of engines is provided with two main condensers, so arranged that one condenser can be used independently of the other in case of one requiring overhaul. These condensers are used in conjunction with the main propelling machinery only. Auxiliary condensers—one in each engine room—fitted with independent engines and pumps, are provided for condensing the steam from all the auxiliary machinery. The main air pumps are worked direct from the main-engine piston. Each of the propellers is 19 feet in diameter, 22 feet 9 inches pitch, and has three blades. Steam is supplied by a set of 43 Belleville boilers, with economizers arranged in groups in four separate stokeholds. The safety valves are loaded to 300 pounds pressure per square inch, the working pressure in the engine room being 250 pounds per square inch. The total heating surface amounts to 71,970 square feet, and the grate area to 2,310 square feet. Air is supplied to the boiler rooms by sixteen fans driven by double-acting steam engines, with four air-pumping engines fitted in the stokeholds, for delivering air to the fires and combustion chambers.

Kent.—This cruiser, of the *Monmouth* class, was launched at Portsmouth on the 6th of March. Her principal characteristics are:

Length between perpendiculars, feet	440
Breadth, extreme, feet	66
Draught, mean, feet	24.5
Displacement, tons	9,800
I.H.P.	21,000
Speed, knots	23
Weight of hull, armor and backing, tons	5,895
Coal at normal displacement, tons	800
bunker capacity, tons	1,600

Battery.—Fourteen 6 inch; ten 12-pounders; three 3-pounders; eight Maxim; two 18-inch tubes.

Protection.—Belt, 4 inches to 2 inches; deck, 3 inches to 2 inches.

The armor belt begins 106 feet from the stern, and ends at the bow in 2-inch plate 11 feet 6 inches wide.

Of the 6-inch guns, four are mounted in 4-inch barbettes, and the remainder in 4-inch casemates.

The machinery has been constructed by Messrs. Hawthorne, Leslie & Co., and consists of two sets of balanced triple-expansion, four-crank engines, and 31 Belleville boilers with economizers, the boiler pressure being 300 pounds and the pressure at the engine 250. The cylinders are 37, 60 and 69 inches in diameter, the stroke being 42 inches. They are supported on inverted Y frames at the back, and on forged pillars at the front, there being two of the latter for each cylinder. The valves of the high and intermediate-pressure cylinders are of the piston type, while those of the low-pressure cylinders are of the treble-ported flat type. These are worked by double eccentric link gear. The engines are reversed by an independent double-cylinder steam-reversing engine working a worm and wormwheel of the all-round type, the clutch arrangement being fitted so that the engines can be reversed by steam or hand. There are two condensers for each engine placed in the wing of the ship. The cooling surface in each is 5,700 square feet. Two air pumps, which are worked by levers from the low-pressure cylinder crossheads, are entirely of gun metal, single acting, and are 23 inches in diameter and 21-inch stroke. The boilers are arranged in three watertight compartments, viz: twelve boilers in the after compartment, eleven in the center, and eight in the forward. They contain a total heating surface of 50,300 square feet, and a grate surface of 1,610 square feet. Of the heating surface, 17,200 square feet is in the economizers.

The keel of the *Cornwall*, a sister ship to the *Kent*, was laid at Pembroke on the 10th of March.

Albemarle and **Montague.**—First-class battleships, of the same class as the *Russell*, described on page 476, were launched

March 5, the former at Chatham, and the latter at Devonport. The machinery of the *Albemarle* will be built by the Thames Iron Works, London, and that of the *Montague* by Laird Brothers, Birkenhead.

Albion.—Owing to defects in the boilers of this battleship, her trials have been delayed since last December. On the 26th of March she completed her thirty-hour coal-consumption trial, maintaining a speed of 16.2 knots and 10,800 I.H.P. On the full-speed trial her speed was 17.8 knots per eight hours. The details of her trial at one-fifth power were given in the last number of the JOURNAL.

Her dimensions are: Length, 390 feet; beam, 74 feet; mean draught, 26 feet; displacement, 12,950 tons. She was designed for 18.25 knots on 13,500 I.H.P. Her battery comprises four 12-inch, twelve 6-inch and eighteen small rapid-fire guns. Her boilers are of the Belleville type, with 10,720 square feet of grate and 33,511 of heating surface.

Implacable.—This new battleship, after completing a thirty-hour trial at one-fifth power, made three unsuccessful trials at four-fifths power before a successful one was had, each one having been interrupted by hot journals. After additional oiling gear was fitted the trials passed off satisfactorily. The results were:

	⅕ power.	⅘ power.	Full power.
Duration, hours	30	30	8
Steam in boilers	220	260	270
at engines	.....	233	243
Revolutions	66	100	108.5
I.H.P	3,265	11,857	15,244
Speed	11.10	16.75	18.22
Coal per I.H.P	.....	1.65	1.88

The *Implacable* is 400 feet long, 75 feet beam, 26 feet 9 inches mean draught and of 15,000 tons displacement.

Hardinge.—A steamer built for the transport service of the Indian Government, has had a satisfactory trial, realizing a speed of 19 knots for six hours. A description of her was given on page 1123 of Volume XII, and, in addition to the particulars there given, it may be stated that her displacement on a mean load draught of 19 feet is 6,520 tons. Her engines were designed

for 8,000 I.H.P. at 110 revolutions per minute. She is built to mount a battery of six 4.7-inch, six 3-pounders and four smaller guns when employed as an auxiliary cruiser. She has accommodations for 1,400 troops, and has been designed with special reference to service in the tropics.

Minerva.—The *Minerva*, cruiser, left Portsmouth, on March 8, for a twenty-four hours' coal and water-consumption trial at 5,000 indicated horsepower, for the information of the Boiler Committee, and returned on the following day after a successful run. She drew 19 feet 2 inches forward and 23 feet 2 inches aft. The steam pressure in her boilers, which are of the cylindrical pattern, was 144 pounds per square inch. The vacuum was 26¾ inches starboard and 26 inches port, and the revolutions 111. The actual indicated horsepower was 5,148, and the speed 16.3 knots. The coal consumption worked out at 1.74 pounds per I.H.P., and the water consumption for all purposes at 15.44 pounds.

Fantome.—A twin-screw sheathed sloop was floated out at Sheerness Dockyard on the 23d of March. She is barkentine rigged, and has the following characteristics:

Length on water line, feet	185
Breadth, feet	33
Draught, mean, feet	11.25
Displacement, tons	1,070
I.H.P.	1,400
Speed, knots	14.25

Her battery comprises six 4-inch, four 3-pounders and two .45-inch Maxims.

The engines and boilers (four Belleville) are building at the Devonport dockyard.

Mutine.—A single-screw sheathed sloop, built by Laird Brothers, Birkenhead, has completed her trials. The principal features of her design are:

Length between perpendiculars, feet	180
Breadth, feet	33
Draught, mean, feet	11.5
Displacement, tons	980
Coal at above displacement, tons	130
I.H.P.	1,400
Speed	13.25

Battery.—Six 4-inch and four 3-pounders.
Engines.—Triple-expansion.
Boilers.—Belleville.
The following are the results of her trials:

Draught, mean, feet and inches	11–7	11–6	11–5
Steam in boilers	170.2	198.7	225.2
at engines	168.4	195.5	215.6
Vacuum	27.1	28.1	26.4
Revolutions	122.1	181.3	206.5
I.H.P.	330	1,041	1,490
Speed, patent log	8.1	12.2	14.55

During the last trial the air pressure was .17 inch, and the speed on the measured mile 13.74 knots.

Pandora.—This cruiser, whose former trials are noted on page 282 of the current volume, has completed a full-power trial lasting seven hours, the results being: Revolutions, 218; I.H.P., 5,187; speed, 18.625.

The *Pandora* was built by the Palmer Shipbuilding Company, Jarrow-on-Tyne. Her dimensions are: Length, 305 feet; beam, 36 feet 9 inches; mean draught, 13 feet 6 inches; displacement 2,200 tons. She mounts eight 4-inch and eight 3-pounders, and two torpedo tubes. Her boilers are of the Belleville type.

Sutlej.—The trials of this cruiser, of the *Cressy* class, built by Messrs. John Brown & Company, Clydebank, were commenced on the 20th of April, when she made a trial of thirty hours' duration at one-fifth power. The conditions were favorable, and the mean results were: Speed, 14.03 knots; I.H.P., 4,679; revolutions, 75.

On the 23d of April she started on another thirty-hour trial at 16,000 I.H.P., but had to abandon it on account of hot bearings. A second attempt was equally unsuccessful, but after fitting new I.P. crank-pin brasses she was successful, making 20.628 knots on four runs over a twenty-three mile measured course, and averaging 16,604 I.H.P. for the thirty hours. The revolutions were 113.5.

Her dimensions are:

Length, feet	440
Beam, feet	69.5
Draught, mean, feet	26.25
Displacement, tons	12,000
I.H.P.	21,000
Speed, knots	21
Coal at above draught, tons	800

Battery.—Two 9.2-inch, twelve 6-inch, and seventeen smaller guns.

Sybille.—The second-class cruiser *Sybille*, of 3,400 tons, 9,000 I.H.P. and 19 knots speed, was wrecked on the morning of January 16th, to the southward of Lambert's Bay, South Africa.

Kangaroo and **Myrmidon.**—Torpedo-boat destroyers recently completed their trials with the following results:

	Kangaroo.	*Myrmidon.*
Speed for 3 hours,	30.03	30.229
Revolutions per minute,	378.8	379.2
I.H.P.,	6,463	6,303

The weather was heavy during the trial of the *Kangaroo.*

These destroyers were built by Palmer's Shipbuilding Company, Jarrow-on-Tyne, and are 215 feet long, 20 feet 9 inches beam, draw 6 feet 8 inches, and have a displacement of 335 tons.

Lively.—On March 15th this torpedo-boat destroyer, built and engined by Messrs. Laird Brothers, Birkenhead, successfully passed her official trial on the Clyde. The following results were obtained on six runs over the Skelmorlie mile:

Steam.	Revolutions.		Speed.	Indicated Horse-power.
	Starboard.	*Port.*		
220	386.8	390.2	29.752	6,061
230	400.0	402.6	30.152	6,501
223	395.6	396.2	30.354	6,371
250	395.5	397.7	29.900	6,323
228	398.7	400.7	30.664	6,465
226	395.0	396.0	29.850	6,396

The mean speed for the three hours was 30.278 knots.

Her coal-consumption trial at 13 knots required 415 I.H.P., and the coal expenditure was 2.25 pounds per I.H.P.

The *Lively's* dimensions are: Length, 210 feet; beam, 20 feet; mean draught 6 feet 8 inches; displacement, 327 tons.

Torpedo Boat No. 98.—The first of four boats building by Messrs. Thornycroft was launched January 22d.

Length between perpendiculars, feet	155
Length on water line feet	160
Beam, feet	17
Draught, aft, feet	8.42
Draught, mean, feet	5.75
Displacement, tons	178
Bunker capacity, tons	40
Load on trial, tons	42
I.H.P	2,850
Speed, knots	25

The armament comprises three 3-pounder guns, and three tubes for 18-inch Whitehead torpedoes, two of which are broadside and one aft. There is but one engine, which is balanced on the Thornycroft system, and is designed to run at 400 revolutions per minute at full power with 220 pounds pressure in the boilers, of which there are two.

Submarine Boats.—The British government has decided to build five boats of the Holland type, the general features of which are practically identical with those now under construction for our Government, and which are clearly shown opposite page 476 of this issue. The following description of the British boats is chiefly from "Engineering."

The dimensions are: 63 feet 4 inches length over all; 11 feet 9-inch beam, and 120 tons displacement submerged. The boats will be provided with means of expelling torpedoes either with the boat stationary, during the run on the surface, or steaming at any speed submerged. The armament consists of one torpedo-expulsion tube at the extreme forward end of the vessel, the muzzle covering opening outward 2 feet below the light-water line. Interlocking safety devices are employed to prevent accident while operating valves for the expulsion of the torpedo.

The general construction of the vessels is such that all portions of the exterior of the hull are free from projections of a nature to be entangled by ropes or other obstacles when submerged, and the lines of the vessel are specially designed to minimize resistance for surface cruising. The plating and frames are to be

of steel of sufficient size and thickness to withstand the pressures of depths not over 100 feet. The seams are to be designed to give high efficiency to the joints. The bulkheads are located not only to insure safety in the event of collision, but to stiffen the hull as a whole. Decks are to be provided throughout the entire length of the interior of the vessel, combined with beams and floors to carry the weight of machinery. The tanks are to be of steel, braced and stiffened according to the requirements, and riveted and caulked absolutely tight. Manholes will be located to allow access to the interiors of all tanks.

The superstructure is to be located to allow of an above-water deck when the vessel is light for surface running, also to have means of stowing anchor and lines and to afford mooring facilities to the vessel. A deck, 31 feet long, will be provided for use on such occasions.

The rudders are of steel plates, supported by skegs at the stern of the vessel, as shown in the elevation. As shall presently be explained, the vessel dives like a porpoise instead of sinking on an even keel, and for this purpose there are horizontal as well as vertical rudders.

The conning tower is of armor steel, the outside diameter being 32 inches and the minimum thickness 4 inches, with ports for observation by the navigator.

The propulsion of the vessel on the surface is effected by an Otto engine of the gasoline type, described in the last number of the JOURNAL.

An electric motor of the waterproof type is provided for giving the vessel a speed of 7 knots when submerged, and is worked by storage batteries having a capacity which will admit of a four hours' submerged run at a speed of 7 knots. Gearing is provided to allow for the charging of the battery, for driving the propeller from the main engine or moving the engine from the main motor, the combinations being effected through clutches, which are operated as desired. Switches, etc., are provided for the safe and efficient distribution of the electric current throughout the vessel. The lighting of the boat is effected by portable

incandescent electric lamps, while there are several ports and openings in the hull to admit daylight.

The ballasting system consists of apparatus for quickly changing the vessel from light to a diving condition, and for keeping her displacement constant in different waters—*i. e.*, in salt or fresh water. The same arrangement is utilized for enabling the navigator to adjust the longitudinal trim when diving, or for compensating for the variable weights installed or expended from time to time, such as discharging torpedoes, etc. The air supply and ventilation are secured by compressed air stored on board the vessel, the gasoline vapors from the engine being carefully excluded by ingenious arrangements. Safety valves are arranged to relieve any excess of pressure in the vessel over that of the atmosphere.

Steering and diving engines are provided, and are fitted with automatic means of moving the rudders to the desired positions to prevent the vessel from inclining to excessive angles during diving or rising, and to keep the depth of submergence constant, as well also as to bring the vessel to a horizontal position at the required depth, and to prevent diving to excessive depths. In addition to these mechanical means, steering and diving can be executed by hand gear if desired. The compasses carried on board the vessel are compensated and adjusted so that the boat can be steered with equal accuracy when submerged as on the surface.

The general operation of the boat may thus be briefly described: Before it is desired to make a dive, the boat is brought to an "awash" condition, with only the conning tower ports above the water. The dive is then made at a small angle until the proper depth is reached, when, by automatic means, the boat is brought to a horizontal position. After the discharge of the torpedo from the fixed bow tube the compensation for the weight of the torpedo is made automatically, causing only a slight change of trim for a few seconds. Provision is made for quick rising and diving, the time of appearance of the conning tower above the water being dependent on the skill of the navigator.

The official trial will be a surface run of ten miles at a speed of 7 knots, and a submerged run of two miles at a speed of 7 knots. At the end of this last run, a service torpedo will be fired at a target 150 feet long by 16 feet deep, the upper edge being awash and at right angles to the course. During the submerged run the boats must not come to the surface more than three times from the time of starting until the discharge of the torpedo, and the duration of each appearance must not exceed one minute. Suitable masts are provided for observing the movements of the boat while submerged.

FRANCE.

The New Shipbuilding Programme.—The new budget provides for the commencement of the construction of two battleships, one armored cruiser, ten torpedo-boat destroyers, twelve torpedo boats and eight submarine boats.

The battleships (A 8 and A 10, *La Republique* and *La Patrie*) will be the design of M. Bertin, and will have the following characteristics:

Length, feet	439
Breadth at water line, feet	79.56
Draught, aft, feet	27.66
Displacement, tons	14,865
Speed, knots	18
I.H.P.	17,235
Coal, normal, tons	905
additional (briquettes), tons	920
Armor, complete belt, inches	11.8 tapering to 3.1
decks, two, inches	2.7 and 1.9
turrets, main, inches	12.6
smaller, inches	5.5
Battery, main	Four 12-inch, eighteen 6.48 inch R. F.
secondary	Twenty-six 47 mm., two 37 mm.
torpedo tubes	Three above water, two submerged.
Engines—vertical, triple-expansion, number	3
Boilers	Water-tube.

The armored cruiser, *Victor Hugo* (C 18), is also from the design of M. Bertin. Her characteristics are—

Length, feet	480.65
Breadth at water line, feet	70.21
Displacement, tons	12,500
Speed, knots	22
I.H.P	27,500
Coal, normal, tons	1,320
additional (briquettes) tons	780
Armor, water-line belt, inches	6.69
Battery, main	Four 7.64-inch, sixteen 6.48-inch.
secondary	Twenty-two 47 mm., two 37 mm.
torpedo tubes, above water	3
submerged	2
Engines, triple-expansion, number	3
Boilers	Water-tube.

The destroyers contemplated are of the following dimensions:

Length, feet	183.73
Breadth, feet	19.49
Draught, aft, feet	9.84
Displacement, tons	303
Speed, knots	28
I.H.P	4,800
Coal, tons	37.5
Battery	One 65-mm., six 47-mm., two tubes.

The type of torpedo boats has not yet been decided, but it is probable that they will be 121 feet long, of 90 tons displacement, and have a speed of 24 knots. They will have a single screw and two boilers, and will carry 10½ tons of coal. They are to be named *Sabre*, *Francisque*, *Dard*, *Baleste*, *Mousqueton*, *Arc*, *Pistolet*, *Bélier*, *Catapulte* and *Bombarde*.

The Submarines, according to the official figures, will be similar to the *Sirene* and *Triton*, now under construction; that is, of the following dimensions:

Length, feet	111.15
Breadth, feet	12.30
Draught, aft, feet	5.25
Displacement, tons	106
Torpedo tubes	4

Motive power: steam for surface runs and electricity when submerged.—Chiefly from "Le Yacht."

"Le Yacht" of later date states that four boats of 70 tons are to be built at Cherbourg, ten at Toulon and six at Rochefort. It

is also reported that three others of different types are under construction for experimental purposes. From this later information the dimensions given above for the *Siréne* and *Triton* do not apply to the newer boats.

Condé.—About the first of the year the keel of this armored cruiser, designed by M. Bertin, was laid at Lorient. Her principal data are:

Length, feet	452.76
Breadth, feet	66.27
Draught, mean, feet	22.97
Displacement, tons	10,000
Speed, knots	21
I.H.P.	20,220
Coal and oil fuel, normal, tons	1,050
total, tons	1,670
Armor, complete water-line belt, slightly reduced at the ends, inches	5.9
citadel, inches	4.7
deck, upper, inches	1.34
lower, inches	1.77
Battery, in barbette turrets	Two 7.64-inch.
in turrets and redoubts	Twelve 6.48-inch R. F.
secondary	Six 100-mm.; eighteen 47-mm.; four 37-mm.
torpedo tubes, above water	3
submerged	2

All the large guns are protected with armor, that for the 7.64-inch being 7.87 inches thick and that for the 6.48-inch 4.72 inches.

She will have triple-screw engines and 28 Belleville boilers. The trials will consist of one at full power for three hours and one at maximum cruising speed for twenty-four hours.—"Le Yacht."

Desaix.—Sheathed armored cruiser launched at St. Nazaire on the 21st of March. The following particulars are from "Le Yacht":

Length, feet	426.5
Breadth, feet	58.66
Draught, mean, feet	23.9
Displacement, tons	7,710
Coal, normal, tons	880
total, tons	1,200
I.H.P.	17,000
Speed, knots	21

There is a complete belt extending between the protective deck and the cellular between deck. This belt is 4.37 inches thick amidships. (The Office of Naval Intelligence and Brassey say 3.94 inches.—ED.)

The battery comprises eight 6.48-inch guns in four armored turrets, four 3.93-inch, ten 47 millimeter and four 37 millimeter, all rapid fire. There will be two torpedo tubes.*

The engines will be of the triple-expansion type, operating three screws.

The *Desaix* is of the same type as the *Kleber*, particulars of whose machinery were given on page 289 of the last number of the JOURNAL.

Iéna.—The trials of this triple-screw battleship, which have been in progress for several months, have finally been completed, with the following results:

Number boilers in use	14	20	20
Duration of trial, hours	6	6	6
I.H.P.	5,504	12,500	9,830
Speed	13.8	17.4	16.3

She has suffered much from hot bearings, which defect has been attributed to light construction of the hull, the claim being made for her that she is one of the few ships built that has a reserve of displacement.

The principal elements of her design are:

Length on water line, feet	400.75
Beam, feet	68.37
Draught, aft, feet	27.50
Displacement, tons	12,052
I.H.P.	15,500
Speed, knots	18
Coal, normal, tons	820
total, tons	1,100
Armor belt, inches	13.78

Armament, four 12-inch; eight 6.48-inch; eight 3.97-inch; sixteen 47-mm., and eighteen smaller guns.

[*The Office of Naval Intelligence gives, from "authoritative sources," the following battery: Ten 6.48-inch, two in middle-line turrets on upper deck and eight in casemates—four each side—on the main deck, four of them having direct fire ahead and four direct fire astern. These instead of the two larger calibers given above.—ED.]

The armor belt is a complete one, but is reduced in thickness at the ends. There are two horizontal armored decks at the level of the upper and lower edges of this belt, the space between being subdivided by the cellular structure, or partial bulkheads usual in French ships. The casemate armor varies in thickness from 2.36 to 4.72 inches.

The 12-inch guns are mounted in pairs, in turrets forward and aft; the 6.48 inch in armored redoubts with 2.75-inch shields.

The engines were built by the Forges et Chantiers de la Méditerranée, and comprise three vertical triple-expansion engines, designed for 15,500 I.H.P. with 125 revolutions per minute. Steam is supplied by twenty Belleville boilers of the economizer type, working at a pressure of 255 pounds per square inch.

Pique.—Torpedo-boat destroyer of 313 tons displacement, designed for a speed of 26 knots with 5,700 I.H.P. Her first official trials took place in October last, but as the speed attained was only 24 knots, it was decided that new screws would be necessary before the required speed could be reached. In February she ran a trial of five hours' duration, maintaining a speed of 22.25 knots with 268 revolutions of her engines, and for one hour a speed of 25.58 knots with 298 revolutions. The latter trial was interrupted on account of a hot guide, but she made another attempt in March, reaching 25.5 knots with 297 revolutions.

Epée.—A boat of the same type as the *Pique*, has had preliminary trials, during which she reached a speed of 25.621 knots. Subsequently she made 19.15 knots with one group of boilers in use.

Torpedo boat No. 245.—This boat, which has been in service but a few months, recently had a boiler accident when running at a speed of 12 knots, which resulted in the severe scalding of three firemen. The boilers are of the Du Temple type. Her dimensions are:

Length, feet	123
Breadth, feet	13.12
Draught, aft, feet	8.69
Displacement, tons	86
Speed, knots	24

GERMANY.

Kaiser Wilhelm der Grosse.—A battleship built at the Germania Werft, Kiel, will soon have her trials.

Her principal characteristics are:

Length between perpendiculars, feet	377.3
Breadth, extreme, feet	66.93
Draught, mean	25.72
Displacement, tons	11,200
Coal at above draught, tons	700
Bunker capacity	900
Speed, knots	18
I.H.P.	13,000

Battery.—Four 24-cm. (9.5-inch) in barbette turrets; twelve 15-cm. (5.9-inch) in casemates; six 15-cm. (5.9-inch) in single turrets; twelve 8.8-cm. (3.46-inch); twelve 37-mm. (1.45-inch); five submerged and one above-water torpedo tubes.

Armor.—Belt, 11.8 to 7.87 inches; barbette turrets, 9.84 inches; 15-cm. guns, 5.90 inches; conning towers, 9.84 and 5.90 inches; protective deck, below water, 2.95 inches; protective deck, above water, 2.36 inches.—From "Schiffbau."

She has a combination of Scotch and water-tube boilers, the latter of the Schultz type, practically the same as the Thornycroft. There are four of the latter, two double and two single-ended, each of the former with 155 square feet of grate and 7,858 of heating surface, and each of the latter with 77.5 square feet of grate and 3,767 of heating surface; making a total grate and heating surface of 465 and 23,250 square feet, respectively. The water-tube boilers are similar to the *Daring* type, but have large water drums, so that men can be sent inside them to plug tubes. The heating surface of the Scotch boilers is 16,900 square feet, and they are intended to supply steam for 5,000 I.H.P., while 8,000 will be supplied by the water-tube boilers.

Freya.—The trials of this cruiser have been completed with satisfactory results, the data being—

Date	March 21.	March 26–27	March 29–30	.....
Duration, hours	6	24	24	72
I.H.P.	10,600	1,200	6,000	6,000

All these trials were completed in thirteen days, the last one being at a speed of 16 knots.

She is a cruiser of 5,650 tons displacement and of the following dimensions: Length, 344.4 feet; beam, 57 feet; draught, 21.67 feet.

She has Niclausse boilers with 775 square feet of grate, and 25,834 of heating surface.

Freya and **Gazelle.**—Messrs. J. and A. Niclausse, through their American representatives, write that the notice of the boilers of these vessels which appeared on page 294 of the last number of the JOURNAL, (translated from "Mittheilungen aus dem Gebiete des Seewesens") does them great injury; that during the trial of the *Freya*, which took place in November last, they had no representative on board; that "the firing was badly managed, the water failed in several boilers and overheating occurred, naturally causing several burnings in the tubes, but * * * the trials were not finally suspended, and after an examination of the boilers they began over again, this time in the presence of our engineer-in-chief. Three trials were made on a single boiler at the rate of combustion of 25, 30 and 35 pounds respectively per square foot of grate. The results were excellent, and it was decided then to proceed to the final trials."

"The boilers of the *Freya* and *Gazelle* have been very badly put up; our engineer-in-chief, on his arrival at Kiel, where he went following the incident of November, found that on the *Freya* they had mounted the tubes very badly."

It appears that the lanterns in the *Freya's* boilers were cut out of solid tubes, and had four openings in them; and that, when in position, the solid portion of the tube was placed uppermost instead of being horizontal, the result being that the upward current was interfered with. After this discovery was made the lanterns were arranged as in the boilers of the *Gazelle*, and the trials at 25, 30 and 35 pounds per square foot of grate, as well as the subsequent ones at full power, and for coal consumption were made under the new conditions.

Torpedo boats S 108 to S 113. These boats or destroyers are to be built by Schichau. Their dimensions are:

Length, feet	206.8
Beam, feet	22.97
Draught, feet	8.86
Displacement, tons	350
I.H.P.	5,400
Speed, knots	27

They will have twin-screw engines and three Thornycroft-Schulz boilers.

HOLLAND.

Ophir.—There has been completed by Yarrow & Co., Poplar, London, the first of three torpedo boats building by that firm for the Dutch Government. She is 160 feet long and of 138 tons displacement, and has engines of 2,000 I.H.P. She mounts two 57-mm. guns and three 18-inch torpedo tubes.

Her trial, with a load of 30 tons on board, gave a mean speed for three hours of 25.3 knots with 1½ inches air pressure.

Subsequent trials were made with a view to test Holden's system of oil burning. A trial was first made with coal only, when a speed of 24½ knots was obtained over a lengthened run. Then the oil burners were started in addition to the coal supply, which remained constant throughout. With the oil and the coal together the speed was immediately increased two knots, *i. e.*, to 26½ knots. The coal burnt throughout the trial was at the rate of 2,800 pounds per hour, and when the oil was introduced, the additional consumption of this fuel was 700 pounds per hour (Borneo oil). In the *Ophir* there are two boilers of equal size, and a further trial was made at a slower speed with oil only, using one boiler, when a speed of 14 knots was readily obtained, burning 500 pounds of oil per hour.

Pangrango.—Another boat of the same dimensions as the *Ophir* was tried April 30, averaging 25.99 knots for three hours with an air pressure of 1½ inches of water.

ITALY.

Emanuele Filiberto.—First-class battleship of the following dimensions:

Length between perpendiculars, feet	344.5
Breadth, extreme, feet	69.29
Draught, mean, feet	24.77
Displacement, tons	9,800

Her principal machinery consists of vertical twin-screw triple-expansion engines, each in a separate watertight compartment, and of twelve cylindrical boilers, six of which are forward and six aft of the engines. Each of the groups of boilers is similarly arranged, three in a compartment, with their backs to a central longitudinal bulkhead, and with two opposite smoke pipes.

The engines have cylinders 43.3, 65.3 and 97.4 inches in diameter by 49.2 inches stroke, and were designed for 13,310 I.H.P. under forced draft, with an air pressure not exceeding $\frac{3}{4}$ inch in the ash pits, the trial to be of one and a half hours' duration. Under natural draft the I.H.P. was to be 8,875 for six hours. The valve gear is of the Stephenson link type, the valves being piston for the H.P. and double-ported slides for the I.P. and L.P.

The boilers are 13.52 feet in diameter and 10.37 feet long, and were designed for a pressure of 155 pounds. There are three corrugated furnaces in each. The total heating surface is 23,897, and the grate surface 850 square feet.

The screws are four bladed, 16.5 feet in diameter, and have a mean pitch of 20 feet.

The following are the results of the official trials:

	Natural draft.	Forced draft.
Duration of trial, hours	6	1.5
Mean draught, feet	24.51	24.64
Displacement, tons	9,660	9,740
Steam pressure in boilers	150	145
at engines	146	143
Air pressure in ash pits, inch	.....	1 to 1.2
Revolutions per minute	94	97.7
I.H.P.	9,526	13,442
Speed, knots	16.8	15.75
Slip, per cent	9.35	18.42
Days out of dock	80	177

The low speed at full power is explained by the fact that she had been out of dock a long time, and that her bottom was foul. —"Rivista Marittima."

Vittorio Emanuele.—A new battleship, the principal data of which are:

Length, feet	435
Beam, feet	73.5
Draught, feet	25.83
Displacement, tons	12,625
Main battery	Two 12-inch.
Secondary battery	Twelve 8-inch.
Tertiary battery	Twelve 3-inch.
Minor guns	Twelve 3-pounders.
Torpedo tubes, submerged	4
Armor belt, inches	10, tapering to 4
deck, inches	4
splinter deck, inches	2
bulkheads, inches	8
barbettes, inches	8
barbette hoods, inches	6
side, inches	6
8-inch turrets, inches	6
conning tower, inches	10
I.H.P	20,000
Speed, knots	22
Coal, normal, tons	1,000
Total tons	2,800

The 12-inch guns are mounted singly in turrets, one forward and one aft, and the 8-inch in pairs in turrets, eight on the main deck and four on the upper deck, the latter being just a little forward of the midship section of the ship.

She has no military masts, but two pole masts for signalling. —From "The Engineer."

This vessel is to be laid down at Spezia, and two others, the *Reina Elina* and the *Roma*, at Castellamare and Venice, respectively.

Giuseppe Garibaldi.—This armored cruiser, a mention of whose successful trial was made on page 299 of the last number of the JOURNAL, has been completed by the contractors, Messrs. Ansaldo, of Sestri Ponente, and delivered to the government. She is the fourth vessel of this name built by the same firm, the first one having been sold to the Argentine Republic, and named *General Garibaldi;* the second to Spain, and named *Cristobal Colon;* and the third to the Argentine Republic, and named *Pueyrredon.* While the four vessels were in outward appearance very much alike, many improvements have been made in the

last one, and as completed she differs little from the *Varese*, described on page 299 of the last number.

The following particulars are from a very complete description of her in "Rivista Marrittima" for March.

Length between perpendiculars, feet	344
on water-line, feet	356.84
including ram, feet	366.02
Breadth, extreme, over frames, feet	59.71
over plating, feet	59.81
over armor, feet	61.38
Draught, normal, forward, feet	22.18
aft, feet	24.54
mean, feet	23.36
Displacement corresponding, tons	7,440
Coal at above displacement, tons	590
bunker capacity, tons	1,230
Tons per inch at load displacement	36.9
Wetted surface, square feet	27,492
Immersed midship section, square feet	1,222
Area of water line plane, square feet	15,199
Coefficient of fineness of I.M.S.	.852
of L.W.L.	.720
block	.518

She has a single military mast with signal yards, and two smoke pipes, one forward and the other aft of the mast.

There are bilge keels 31 inches deep amidships and 19.7 at the ends, extending for a distance of 114.8 feet.

The double bottom extends from the forward bulkhead of the forward coal bunkers to the forward bulkhead of the aftermost ones, a distance of 167.3 feet.

The frames are spaced 31.9 inches in the engine space, 32.5 in the boiler and bunker spaces, and 31.5 elsewhere.

Protection.—There is a complete belt extending between the protective and the berth decks. It is 2.76 inches thick at the bow and stern above water, and 3.54 inches along the lower edge, and 5.9 inches elsewhere, as well as for the guns on the battery deck.

Battery.—One 10-inch in a revolving turret, forward; two 8-inch in a turret, aft; fourteen 6-inch, of which four are on the

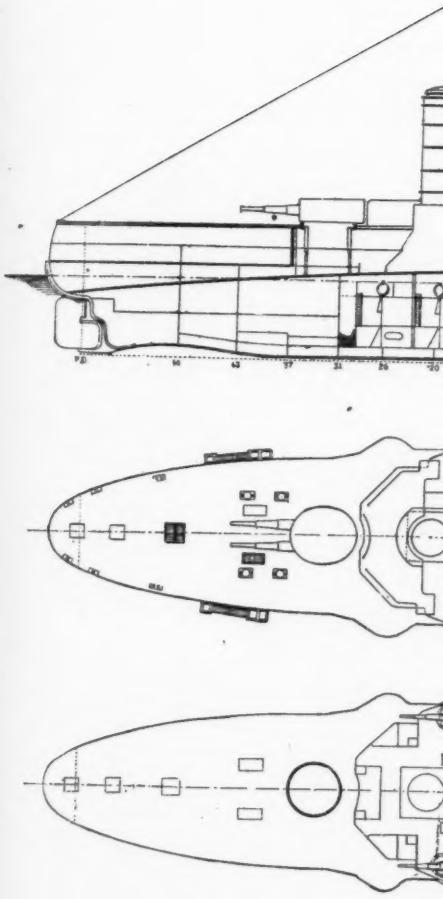
upper deck, and ten on the battery deck, six of which cannot fire in line with the keel, and are arranged in opposite sponsons; ten 3-inch, six on the upper deck, and two aft and two forward on the battery deck; six 47-mm.; two 3-inch boat guns; and two Maxim-Nordenfelts in the military tops. She also has two above-water torpedo tubes and carries eight torpedoes.

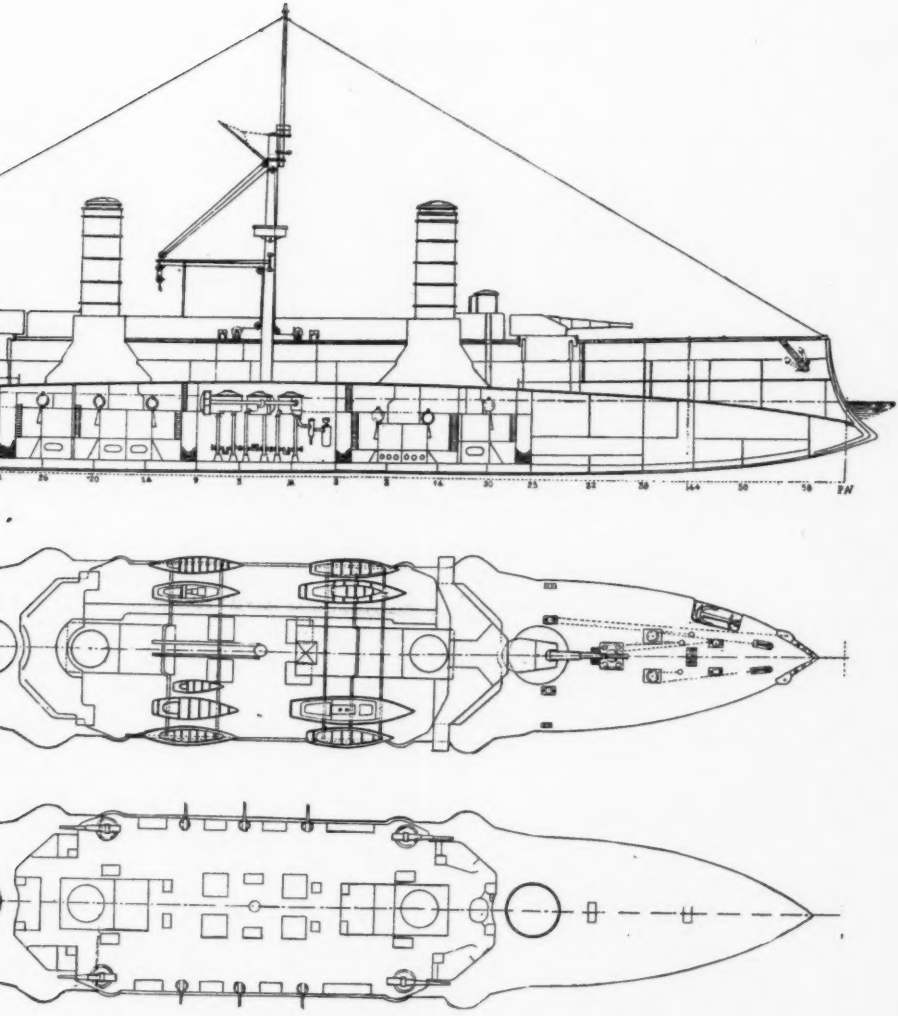
The machinery consists of twin-screw, vertical triple-expansion engines, wholly beneath the protective deck, and of water-tube boilers of the Niclausse type.

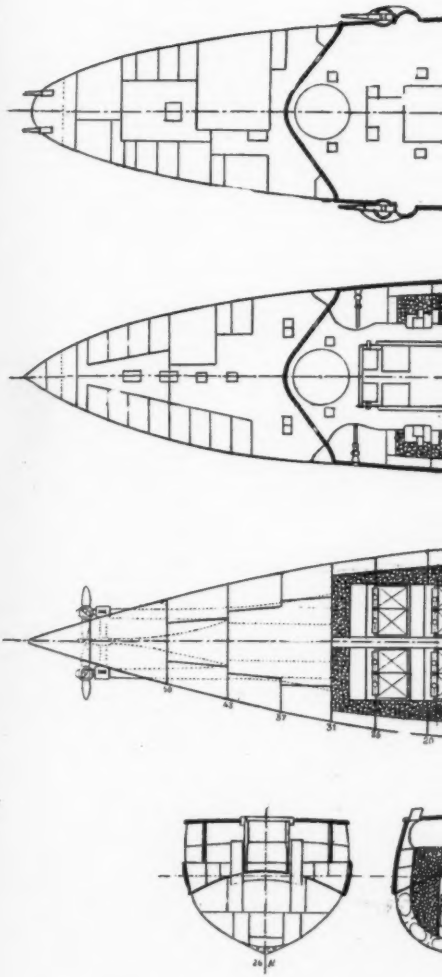
The boilers are twenty-four in number, twelve forward and twelve aft of the engines, arranged as shown in the cuts. The tubes are of steel, solid drawn, and the lanterns of malleable iron.

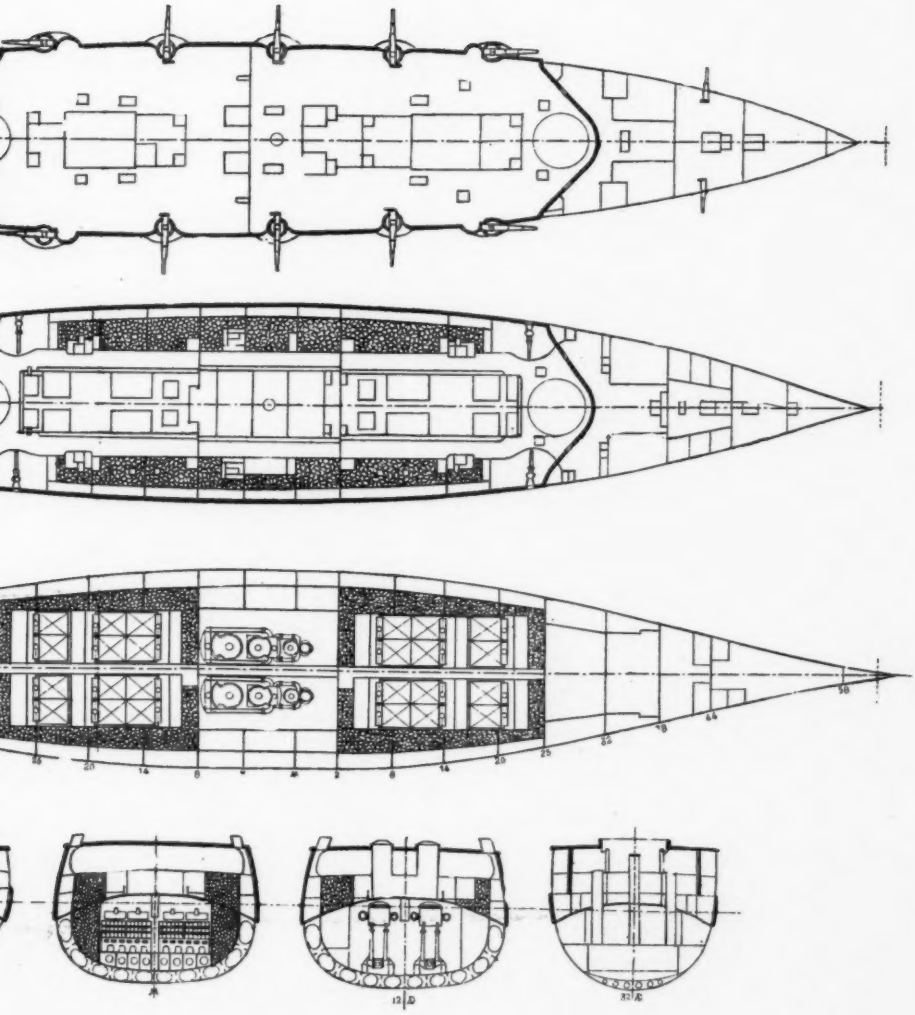
Engines.—

Working pressure, pounds	155
Cylinders, diameter, inches	42½, 63 and 93
Stroke of pistons, inches	46
Piston rods, diameter, inches	8.5
Crosshead, length of pins, inches	11.81
diameter of pins, inches	9.5
Connecting rod, length, inches	92
Crank shaft, external diameter, inches	16
internal diameter, inches	8
Crank pins, external diameter, inches	16.5
internal diameter, inches	8
length, inches	19
Bearings, length, inches	19
Line shaft, external diameter, inches	15
internal diameter, inches	7.5
Length of line-shaft bearings, inches	21.6
Condenser, cooling surface each, square feet	6,910
tubes, number	4,159
diameter, inch	¾
thickness, inch	.10
length, feet	8.63
Air pump, main, diameter, inches	33
stroke, inches	21
Circulating pump, runner, inches	48
Auxiliary condenser, cooling surface each, square feet	1,614
tubes, ¾-inch, number	854
length, feet	5









Boilers.—

Steam pressure, pounds	214
Number	24
Grate surface, square feet	1,090
Heating surface, square feet	35,217
Length of one boiler, feet	9.15
Width, feet	7.64
Height from fire-room floor to dome, feet	12.89
Furnace, length, feet	7.15
width, feet	6.76
Grate, length, feet	6.73
width, feet	6.76
surface, feet	45.42
Tubes, evaporating, number	216
length beyond header	7.38
diameter, inches	3.23
thickness, inch	.138
Lantern, length, inches	7.56
Number of elements	12
Heating surface, each boiler, square feet	1,467
Evaporating surface, each boiler, square feet	18.73
Water space, cubic feet	97.43
Steam space, cubic feet	1.48
Fans for forced draft	12
diameter, inches	60
Cross section of ventilators for four boilers, square feet	16.91
both smoke pipes, square feet	156.08

Screws.—Four bladed:

Diameter, feet	16
Pitch, greatest, feet	25
least, feet	21
mean, feet	23
Helicoidal area, square feet	86

Two compartments of the double bottom, holding 72 tons, are utilized as reserve feed-water tanks.

The following are the data of the official trials under natural and forced draft:

	Natural draft.	Forced draft.
Mean draught, feet	23.29	23.26
Duration of trial, hours	6	1.5
Steam pressure, boilers, pounds	176.6	204.3
engines, pounds	146	146
Air pressure, inch of water	....	.51
Vacuum, inches	26.5	25.5

Revolutions per minute	89.2	105.26
I.H.P.	9,812	14,511
Speed, measured mile	16.12	19.66

The bottom was not clean on the first trial, which explains the comparatively low speed for the revolutions; on the second trial, she had just come out of dock.

On these trials, the fires were managed according to the instructions of the Niclausse company, the pressure being raised gradually for an hour and a half before commencing the trial.

[It will be remembered that this is the vessel on which two boilers were disabled during one of her trials. See JOURNAL, Vol. XII, page 1047.]

Distribution of Weights.	Tons.
Hull and fittings	3,049 257
mechanism	266.149
Armor and fastenings	1,240.346
Teak backing and bolts	87.565
Propelling machinery and water	1,086.881
Main and secondary battery	450.397
Ammunition	186.300
Store-room fittings, gear, etc.	51.721
Torpedoes and torpedo equipment	17.200
Electric plant	44.818
Mast, rigging, awnings, canvas	37.327
Anchors, chains and buoys	85.221
Boats	29.326
Binnacles, voice pipes, signals	8.786
Stores	30.000
Crew, provisions and water	136.000
Reserve feed water	33.000
Coal at normal draught	600.000
Total	7,440.294

The machinery weights are subdivided as follows:	Tons.
Shafts, screws, bearings, etc.	123.478
Main and auxiliary engines and their piping	397.580
Boilers, pipes, smoke pipes	423 427
Water in boilers and condensers	73.400
Spare parts, tools, ladders, gratings, etc.	68.996

Electric plant.—Electric light and power are supplied by four generating sets, each 33 kilowatt and 110 volts. There are about 600 lamps in the ship.

The motors are:

6 of 30 ampères for centrifugal fans.
3 of 20 ampères for centrifugal fans.
2 of 12 ampères for screw fans.
2 of 8 ampères for screw fans.
2 (1 spare) of 23-H.P. for moving the 10-inch turrets through large arcs.
1 of 2.5-H.P. for moving them through small arcs.
2 (1 spare) of 17-H.P. and one of 2.5-H.P. for similar movement of the 8-inch turret.
2 6-H.P. ammunition hoists.
5 4-H.P. ammunition hoists.
1 4-H.P. hoist for 8-inch charges.
1 1-H.P. hoist for 8-inch projectiles.
1 4-H.P. motor for kneading.
4 1-H.P. motors for workshop.

The fans above mentioned are for ventilation, the centrifugal fans forcing air in and the screw ones exhausting it, the two large screw fans being in the engine rooms.

Workshop.—The workshop is provided with the following tools: One large lathe, one radial drill, one horizontal planer, one milling machine, one small foot lathe, one hand-power drill, and one emery wheel, hand.

The machine tools are operated by electric motors.

NORWAY.

Submarine Boat.—Admiral Börresen, Chief of the General Staff of the Norwegian Navy, has asked, through the medium of a supplementary budget, the sum of $175,000 for the construction of a submarine boat in accordance with the system invented by the builder of the *Holland*. The admiral, in his request, declares that "these vessels will have a speed of 9 knots on the surface and 7 knots under water. They will, too, if the hopes of their constructors are justified, be able to sink 10 meters under water and to remain continuously submerged during the space of four hours." Admiral Börresen says that he fully believes that the hopes of the constructors will be realized.

RUSSIA.

Tsarevitch or **Cesarevitch.**—Battleship launched from the Forges et Chantiers de la Méditerranée, at La Seyne, on the 2d

of March. She is the design of M. Lagane, and is of the following dimensions:

Length, feet	388.79
Breadth, extreme, feet	76.11
Draught, mean, feet	26 25
Displacement, tons	13,110
I.H.P.	16,075
Speed, knots	18
Coal, normal, tons	800
total, tons	1,350

Battery.—Four 12-inch, 40-caliber guns, mounted in pairs in turrets; twelve 6-inch, 45-caliber, rapid-fire guns, also in pairs in turrets; twenty 2.95-inch, 50-caliber guns; twenty 47-millimeter and six 37-millimeter Hotchkiss; two Baranowsky 2½-inch field guns, and six torpedo tubes, of which four are above water and two submerged. All the guns are well protected, and have a large arc of fire. Two 12-inch and eight 6-inch can be fired directly ahead or astern, and four 12-inch and six 6-inch on either broadside. The 12-inch and 6-inch guns are worked by electric power.

Protection.—There is a complete water-line belt 1.64 feet above and 4.92 feet below the water line; amidships it is 9.84 inches thick at its upper edge and 6.69 inches at the lower edge, and is reduced at the ends to one-third this thickness. Above this armor there is a belt 8.66 inches thick, which protects the armored middle deck. This deck is included between two protective decks, the first of which is in line with the upper edge of the belt. It is of nickel-steel, 2.56 inches thick. The second deck is formed of two thicknesses of steel .787 inch in thickness. This last deck is trapezoidal in form; that is, it is flat on the upper part, slopes for a distance of two meters and then goes down to 7 meters below the water line, where it joins the outside plating.

The ammunition tubes are protected by armor from 10.15 to 11.18 inches thick; the 6-inch turrets by 6.69 inches; the conning tower by 9.92 inches, and the signal tube by 5.12 inches.

The hull is divided into numerous watertight compartments, with a double bottom beneath the engines, boilers and ammuni-

tion rooms. The vitals are protected by a deck, which extends the full length of the vessel; it is 0.9 inch on the flat, 2.7 on the slopes along the central portion, and 2.1 inches at the ends, and is formed of two plates, the upper of which is of nickel-steel.

Besides the usual pulling boats she carries four steam launches and two 56-foot torpedo boats.

The engines are twin-screw, vertical, triple-expansion, and are supplied with steam by twenty Belleville boilers working under a pressure of 270 pounds.—"Le Yacht."

Bogatyr.—Some particulars of this cruiser were given on page 303 of the last number of the JOURNAL. The following are from "Engineering":

Length over all, feet	440.2
on water line, feet	*433
Breadth, extreme	54.45
Draught, mean	20.83
Displacement, tons	6,750
I.H.P.	20,000
Speed, knots	23
Coal at above displacement, tons	720
total, tons	1,100

Battery.—Twelve 5.9-inch; twelve 2.95-inch; six 47-mm.; one 2.56 inch boat gun; two 37-mm.; six torpedo tubes, two of which are submerged.

* This is given elsewhere as 416.7 feet.

Four of the 5.9-inch guns are mounted in pairs in turrets, one forward and one aft, and the remainder in armored casemates. The turrets are protected by armor 4.9 inches thick on the front and 3.5 inches at the rear. The casemate armor is of two plates, the outer 3.1 and the inner 1.38 inches thick. The other guns are protected by shields. The ammunition hoists for the turret guns are protected by 3.1 inches of armor, and those for the casemate guns by 2.36 inches; they can be worked by hand or by electric power.

There is a conning tower forward protected by 5.5 inches of nickel-steel on the sides and 3.5 inches on the top.

The vessel has two masts with signal yards. Six searchlights are placed on bridges, two on the forward bridge, and two on a special bridge forward, and two aft.

There are two triple-expansion engines and sixteen Normand boilers, constructed by the Vulcan Works and fitted with every modern requirement. The moving parts of the main engines are balanced according to Schlick's patent. The boilers work under a pressure of 256 pounds.

The vessel will be well ventilated, heated by steam and lighted by electricity. There are four large and two small dynamos which supply the power for the electric light, the ammunition lifts, the numerous ventilating engines and the searchlights. The steering apparatus, windlasses, boat-lifting gear, pumps, &c., will be worked by steam. The vessel carries two steamboats, one petroleum-motor boat, and seven pulling boats. The boats are all built of thin steel, except the small pulling boats.

The *Bogatyr* will carry 21 officers, 2 non-commissioned officers and 550 men, for whom high and airy quarters have been provided. The use of wood throughout the vessel has been cut down to the smallest possible limits. All decks are of steel, and only the exposed ones are planked with teak to protect them from climatic influences. The inner decks are covered with linoleum. Most of the furniture is built of thin steel, also all the cabin partitions.

Gromoboi.—The engine trials of this first-class armored cruiser, a notice of which appeared on page 304 of the current volume, were concluded last October with the following results:

	Port.	Center.	Starboard.
Steam at engine, pounds	165	171	173
Revolutions per minute	123	117.53	124.23
I.H.P.	5,165	5,274	5,057
Total	15,496		

There are thirty Belleville boilers with 47,021 square feet of heating surface.—"Jour. R. U. S. Inst."

Imperator Nicolai I.—The trials of the machinery of this battleship, after having had Belleville boilers substituted for her old cylindrical ones, proved unsatisfactory, the I.H.P. developed being about 5,000 instead of 8,000 contemplated. The failure is attributed to lack of boiler power, there being but 17,875 square

feet of heating surface in the boilers and economizers, 7,312 of which are in the latter.—"Jour. R. U. S. Inst."

The *Nicolai I* is a sheathed ship built in 1888. She is 326 feet long, has a beam of 67 feet, and on a draught of 23 feet displaces 9,672 tons.

Smolensk.—Messrs. R. & W. Hawthorne, Leslie & Co., Newcastle-on-Tyne, launched on March 7 a twin-screw vessel of the following dimensions for the Russian volunteer fleet.

Length, feet	506
Breadth, feet	58
Depth, feet	37
Speed, knots	20

She has been built to trade between Russia and the East, and is intended to carry troops and cargo in time of peace and to be used as a cruiser in time of war. She has accommodation for 1,500 troops, in addition to passengers. As a cruiser she will mount sixteen R.F. guns.

Her machinery consists of two sets of triple-expansion engines, each having six cylinders, two 26 inches, two 44 inches and two 75 inches, with a stroke of 48 inches, and fitted with Marshall valve gear. To obtain a high economy at half-power, the arrangement of the cylinders is such that one high, one intermediate and one low-pressure can be thrown out of action on each shaft. The arrangement is somewhat similar to that adopted by the same firm for the engines of the Chilian training ship *General Baquedano*. In that ship there are six cylinders, with each pair of H.P., I.P. and L.P. adjacent, with their cranks opposite, and arranged in the order H.P., I.P., L.P. from forward. In the *Smolensk* the I.P. cylinders are at the ends, the H.P. next in order from each end, and the L.P. in the center and adjacent. The course of the steam is forward H.P., after I.P., and after L.P.; after H.P., forward I.P., and forward L.P. The crank shaft is in two interchangeable sections, each section having three crank arms for the two opposite cranks at the end, and two for one L.P. cylinder.

Steam will be furnished by twenty-four Belleville boilers, in three compartments, working at a pressure of 250 pounds.

Ocean.—A training ship for machinists and firemen has been ordered at Kiel. She will be of 12,000 tons displacement, with a maximum speed of 18 knots, and will be fitted with all the auxiliary machinery usually found in battleships, and with boilers of the Schulz, Belleville, Niclausse and Yarrow types. In addition to her duty as a training ship, she is to be used as a collier, her own coal supply being sufficient for 10,000 miles at 10 knots. (See page 304 of the last number of JOURNAL.)

SWEDEN.

———.—The following description of a design of a cruiser that has been prepared for the Swedish Government is from "The Engineer," London, but it is not clear that the vessel has existence except on paper:

Length, feet	328
Beam, about, feet	50
Draught, about, feet	17
Displacement, tons	4,000
Armament, eight 45-caliber, 6-inch Q.F. (Bofors); twelve 6-pounder Q.F. (Bofors); two submerged tubes (Elswick).	
Armor (Kruppized), double turtle-back deck; eight turrets, 4-inch or 5-inch armored hoists to each; armored hoists, two, for 6-pounders; armored conning tower; armored connecting tube; complete cellulose belt rising 3 feet above the waterline.	
Speed	22 knots.
Boilers	Yarrow.

It will be noted that the ship can fire six of her eight 6-inch pieces on the broadside—that is to say, just as many as the British 5,900-ton *Highflyer*, and these pieces, unlike the *Highflyer's*, are protected very thoroughly. Each gun is in a closed turret, and each turret is balanced and revolves on its armored hoist. Nothing carried by any cruiser afloat could hurt these turrets. Even if only 4 inches thick, this amount of Krupp armor, inclined as it is on Swedish turrets, is equal to from 20 inches to 24 inches of vertical wrought iron. On paper, therefore, the ship is superior to anything of her size built or building. Four of the guns have arcs of 270 degrees, the other four of 180 degrees.

The problem is, how will the superposed turrets stand the test of battle? They fire over each other, in the end-on position. Swedes say that experiments have been carried out very fully, and that no harm results to the people underneath. This is a hard statement to swallow, but it is worthy of note that the firing over would only very rarely be required. In all normal positions there is no interference. Swedish officers have no faith in a pair of guns in a turret for small ships; they consider the shock of the recoil to be too great, and here they are probably reasonable. Certainly to have had four turrets with the guns in pairs would have been a bold experiment, nor is it one that looks promising.

MERCHANT STEAMERS.

Celtic.—The White Star steamer *Celtic*, which was launched from the yard of Messrs. Harland and Wolff, at Belfast, on Thursday, April 4th, has the distinction of being the largest ship in point of gross tonnage and of displacement tonnage that has yet been built; although, in point of length, and particularly in speed, she is excelled—the *Oceanic*, built at the same yard, and also for the White Star Line, being longer; while a new high-speed ship being built at the works of the Vulcan Company at Stettin, in Germany—the *Wilhelm der Zweite*—is longer than both these ships, and promises to be faster than any merchant ship afloat.

The *Celtic* represents a distinctly interesting type, which promises a large financial reward; for, with her speed of from 16 to 16½ knots, her coal bill will be very much less than that of many of her competitors on the Atlantic (estimated at 260 tons a day), while, at the same time, she is certainly not deficient in any of the comforts provided on the faster ships. She carries a very much larger number of passengers in the steerage, although fewer first and second, than in some of the other ships, her total of first-class passengers being 347, of the second-class 160, while in the steerage she takes 2,352. This proportion of cabin to saloon passengers has been determined with peculiar reference to the aggregate number of passengers crossing the Atlantic, so that the White Star Line are determined to secure full passenger lists even though the average rate paid per passenger may not be so high as with some of the faster ships; and from this point of view their financial results will doubtless be even more satisfactory on an average of voyages, or in a year, than with faster ships, because the number of passengers crossing the Atlantic who can afford to pay the high rates exacted on the record-racing steamers is relatively small, and in the winter season there are practically no such passengers. Again, in order to attain the

high speed, it has been found practically impossible to carry any cargo, whereas in the *Celtic* something like 13,000 tons of cargo may be carried, which, while adding to the revenue, almost of necessity means a steadier, and therefore a more comfortable, sea ship for passengers. The question, however, has its other side, and there can be no doubt that for advertising purposes the fast ship is a valuable acquisition, and provided she secures the best of the traffic, the financial results need not be unsatisfactory.

Her dimensions are—

Length over all, feet	698.67
on water line, feet	680.75
Breadth, feet	75.38
Depth, molded, feet	49
Gross tonnage	20,880
Net tonnage	13,650
Draught, load, feet	36.5
Displacement, load, tons	*37,700
I.H.P.	14,000
Speed	16.5

* Given elsewhere as 36,700.

Some idea of the immense weight involved in the vessel may be formed from the fact that her launching displacement was 14,259 tons upon a draught forward of 15 feet 4 inches and aft of 17 feet 2 inches, giving an average of 16 feet 3 inches. This is the heaviest displacement of any ship launched, considerably exceeding that of the *Oceanic*. The launching ways were 5 feet wide, and were partly of oak and partly of pine, the oak being used on the permanent ways for the half of the length nearest the water, and on the sliding way for the part under the bow cradle, so that when the ship first floated at the stern the stronger timber took up the greater pressure exerted at the forward end The maximum dip at the stern was 35 feet; the temperature of the water was 45 degrees; and the vessel was brought up 345 feet from the end of the ways, four anchors out of the six provided being sufficient for this purpose. The time taken from the beginning of movement until the ship was afloat was $54\frac{2}{6}$ seconds, the maximum speed attained being estimated at 12 miles per hour.

The ship is built upon the double-bottom cellular system, a flat bar keel 4 inches thick being used, which is riveted to the skin plating, of double thickness, and to angle bars on the vertical inner keel. This, with the keel strake, was doubled and riveted by hydraulic power. Indeed, a large part of the riveting was done by this means, including the top strakes—the sheer strake and the two strakes below—the stringer and the inner stringer that are usually doubled in these large ships, the floors and inner keel strake, all the intercostals in the regions of the machinery spaces, the side plating of the tanks and the bracket, with the beam knees as well as the intercostals between the beams, so that quite 10 per cent. of the hull riveting was done by machine. The riveter used had a 7-foot gap, and weighed about seven tons. It was carried on the large gantry crane, which proved a special advantage in the construction of this ship. The rivets in such cases were $1\frac{1}{4}$ inches of steel, and the plating was from $1\frac{1}{8}$ to $1\frac{1}{4}$ inches thick. There are six longitudinals in the double bottom, three on each side of the inner keel, with 'thwartship divisions. The frame brackets are attached to margin plates by double angles. The frames are of channel section, and are spaced at 34 inches apart; the deck beams are also channels, and there is one for each frame. The shell plates of the ship average 30 feet by 5 feet, and are on an average $1\frac{1}{4}$ inches thick, weighing about four tons. The plates are scarped except where the bilge keels are fitted; these are 250 feet long and 18 inches deep, and the shell plating at the bilge strake is doubled; the straps being quadruple riveted on each side of the openings. From these particulars it will at once be recognized that the ship is of great strength to withstand the hogging and sagging stresses which she will experience in her work.

The stem is of steel, and it may be said that neither at bow nor stern has the deadwood of the ship been cut away to the same extent as in some of the preceding ships. Experience, we understand, has shown that this system, especially aft, has not tended to improve the steering qualities of the vessel, although it may improve the flow of water to the propellers. The propellers in the *Celtic* are only nine inches apart, and an aperture has

been made corresponding to that in the single-screw ship. The "spectacle" frame, now usual in all Harland and Wolff's ships, has, of course, been adopted, and the stern post is cored out to obviate rivets being passed through from one side to the other, enclosing two shell plates and both sides of the frame. With the use of manganese-bronze propellers and a forged-steel framing, it was found that pitting took place in the framing, and Mr. Horsburgh, superintending engineer of the White Star Line, introduced a simple expedient, which has proved very effective. To that part of the stern frame which is directly opposite the propellers, and forms the post for the rudder, there is cast direct a shield of white metal, so that no corrosive effect takes place. This has been tried on several of the White Star boats, and has proved very satisfactory.

The interior of the ship is, of course, divided into numerous watertight compartments by 'thwartship bulkheads, which are stiffened, according to the regulations of the Bulkhead Committee. There are nine decks in the *Celtic:* The lower orlop, the orlop, the lower, middle, upper, bridge, upper bridge, boat and sun decks. The latter three extend only along the central part of the ship, while the others are included within the molded dimensions of the ship, and are only interrupted by the machinery spaces. The first-class passengers are provided for in the central part of the ship on the upper, the bridge, the upper bridge and the boat decks.

The dining saloon is on the upper deck, and occupies the full width of the ship, and the library and smoking room are also on the same level. There are a large number of single-berth cabins in the ship. The second-class passengers are provided for in the after part of the ship upon the upper and bridge decks. The third-class accommodation is on the upper, middle, and lower decks, in state rooms and open berths. The open berths are removable, and are arranged in top and bottom tiers fixed back to back. The officers are on the upper bridge deck.

The ship thus carries 2,859 passengers, and the crew totals 335, made up of 64 deck hands, 92 in the machinery section, with 179 stewards.

The main propelling engines are of the quadruple-expansion type, balanced so as to minimize vibration. The cylinders work on four cranks, the arrangement of cylinders and valves from the forward end being as follows: High pressure, with next its piston valve, then the second intermediate with its piston valve, a double-ported slide valve with a balance piston on the top for the low pressure, which comes next, then the first intermediate cylinder, with, finally, its piston valve. The arrangement of valves thus differs slightly from that in the Yarrow-Schlick-Tweedy system in respect that the high-pressure valve is between the high-pressure cylinder and the second intermediate, instead of being at the forward end; but the centers of the high-pressure and second intermediate cylinders are about the same as the distance apart of the other two cylinders of the engine. Each cylinder is a separate casting, supported in front on the A frame; while at the back there is a condenser incorporated into the framing of the low-pressure and first intermediate cylinders. The air, bilge and sanitary pumps are worked by levers from the crossheads, but the centrifugal pumps are operated by separate engines. Weir feed pumps are used for the main and auxiliary feed to the boiler.

The principal dimensions of the machinery are:

Steam pressure, pounds	210
Cylinders, H.P., diameter, inches	33
first I.P., diameter, inches	47½
second I.P., diameter, inches	68½
L.P., diameter, inches	98
Stroke, inches	63
Connecting rod, length, inches	141½
Crank shaft, diameter, inches	19½
Crank pins, diameter, inches	20
Line shaft, diameter, inches	18
Propeller shaft, diameter, inches	19½
Propeller, 3-bladed, diameter, feet	20
Condensing surface, each condenser, square feet	9,000
Boilers, number	8
diameter, feet and inches	15–9
length, feet and inches	19–6
grate surface, square feet	1,014
heating surface, square feet	41,680
Smoke pipe, height above grate, feet	120

In the following table are given the principal dimensions of the most noteworthy transatlantic steamers.

Vessel.	Length.	Breadth.	Depth.	Gross tons.
	Feet. *Ins.*	*Feet.* *Ins.*	*Feet.* *Ins.*	
Great Eastern	691 0	82 8	48 2	18,915
Britannic	468 0	45 2	33 7	5,004
City of Rome	600 0	52 3	37 0	8,144
Alaska	520 0	50 0	38 0	6,400
Etruria	520 0	57 3	38 2	7,718
Paris	560 0	63 2	39 2	10,500
Teutonic	582 0	57 8	39 2	9,984
Fürst Bismark	520 0	57 6	38 0	8,874
La Touraine	540 0	56 0	34 6	9,209
Campania	620 0	65 0	43 0	12,950
Kaiser Wilhelm der Grosse	648 0	66 0	43 0	14,349
Oceanic	705 6	68 0	49 0	17,274
Deutschland	684 0	67 0	44 0	16,200
Celtic	698 8	75 4	49 0	20,880

—Chiefly from "Engineering."

Deutschland.—The issue of the "Zeitschrift des Vereines Deutscher Ingenieure," of November 3, 1900, contains a complete description of the hull and machinery of this vessel, with numerous illustrations of the internal furnishing, and reproduction of some of the machinery drawings; and from this description, which has been separately issued by the Hamburg-American Company, the data that follow have been taken.

She was built by the Vulcan Company, at Stettin, and complies with all the requirements of the German Admiralty for an auxiliary cruiser. In outward appearance, she has a straight stem and an elliptical stern, four smoke pipes and two masts. Her dimensions are—

Length over all, feet	684
between perpendiculars, feet	662.74
Breadth, extreme, feet	67
Depth, feet	44
Deadweight capacity, tons	5,840
Draught in fresh water, feet	29
Load draught at sea, feet	28.54
Displacement, tons	23,200
Gross tonnage	16,200

The contract for her construction required that, at a mean draught of 26 feet, her mean speed for six voyages should not

be less than 22 knots of 6,076 feet, and that the indicated horse-power, on a six-hour trial at 23 knots, should not fall below 33,000.

There are 272 frames, the spacing of which is (0 being aft):

	Inches.		Inches.
0 to 96	29.92	246 to 247	27.56
96 to 193	29.53	247 to 248	26.38
193 to 245	29.92	248 to 249	25.20
245 to 246	28.74	249 to 272	24.01

She is divided into seventeen watertight compartments, which are of such size that she will float with two adjacent ones full of water.

The stem and stern post are of wrought iron, as are also the rudder stock and frame, these castings weighing respectively 7.7, 80.7 and 26.57 tons. The rudder is wholly below the waterline.

She was launched on the 10th of January, 1900, at which time her weight was 9,300 tons. The launching ways had an inclination of 5.5 feet in 100; the cradles were 581 feet long, 3.61 feet wide for 548 feet, and 4.66 feet for the remainder. The total surface was 2,107 square feet, and the quantity of tallow used was 10,582 pounds.

The double bottom extends from frame 26 to frame 241, and is divided into twenty-two compartments, of which four beneath the boilers, with a capacity of 10,950 cubic feet, are used as reserve feed tanks, and two abaft the engine rooms, of 8,300 cubic feet, as fresh-water tanks. Besides the latter, there are other tanks for drinking water with a capacity of 6,000 cubic feet. The compartments at the forward and after ends of the double bottom are used for water ballast.

The coal bunkers extend from frame 90 to frame 207, and have a capacity of 4,820 tons.

The crew numbers 543, of whom 15 are deck officers, mail clerks and quartermasters, 1 doctor, 1 purser and 1 chief steward; 53 engineers, assistants and oilers, 201 firemen, 218 stewards and cooks, and 54 seamen, carpenters and helmsmen.

There are accommodations in 260 rooms for 693 first-class passengers on the upper, main and promenade decks, besides

single rooms on the deck below. There are 99 rooms in the after part of the ship on the upper, main and 'tween decks for 302 second-class passengers, and accommodations on the 'tween decks for 288 of the third-class.

Electric power for lighting and for a portion of the ventilation is furnished by three large and two small dynamos, of respectively 700 and 400 ampères and 110 volts. The engines for the former are 11.81 and 19.68 by 9.84 inches, and those of the latter 10.63 and 17.72 by 7.87 inches. There are about 2,500 lights in the ship, of which the masthead, the stern and the green side lights are of 50 candlepower, the red side light of 32, and the others of 25 candlepower. One of the dynamos is on the main deck near the forward engine room bulkhead, and the others in a room aft of the engine room, in the after part of which is a refrigerating engine which maintains the several meat and provision rooms at a temperature of 23 degrees Fahrenheit. Aft of this room is the work shop.

The following auxiliaries are installed for deck use:

2 anchor hoists on the turtle back worked by two-cylinder engines on the deck below, with cylinders 17 by 14 inches;

4 winches, two on the turtle back and two on the poop, each worked by two-cylinder engines 15 by 12 inches;

5 winches with cylinders 6 by 10 inches and one 7 by 10.

The are four anchors, two of the Hall stockless pattern weighing 13,224 and 11,000 pounds, one Trottman of 4,564 pounds, and a fourth of 2,281 pounds. The chain for the main anchors is 3.07 inches.

There are two steering engines, each of the same size, placed in adjoining compartments aft. Each has two cylinders 12 inches diameter and 12 inches stroke.

The main engines and their auxiliary machinery occupy the space from frame 55 to frame 90.

Engines.—The main engines are of the quadruple-expansion type, balanced according to the Yarrow-Schlick-Tweedy system. Each consists of six cylinders, of which two are H.P. and two L.P., the H.P. and L.P. being arranged tandem and situated between the 1st I.P. and 2d I.P., the latter of which is placed aft. There

is one piston valve for each H.P. cylinder, and two for each I.P., slide valves being used for the L.P. All cylinders are jacketed and the liners of all are 1.57 inches thick. The H.P. cylinders were tested by water pressure to 284 pounds, the I.P. cylinders to 185 and 100, and the L.P. to 42.7 pounds. The pistons are of cast steel and of different weight, as determined by the balancing system. The frames are of cast steel, as are also the bedplates, which, with the thrust pedestal, is in eleven sections for each engine.

The crank shafts are of nickel-steel, each in four sections, the cranks set as follows: No. 1 (1st I.P.), 63 degrees 20 minutes ahead of No. 4 (2d I.P.); the latter 94 degrees 50 minutes ahead of No. 2 (forward L.P.); No. 2, 107 degrees ahead of No. 3 (after L.P.), and No. 3, 94 degrees 50 minutes ahead of No. 1. The balance weights are on the 1st and 4th cranks.

The throttle can be worked by hand or by a steam and hydraulic control cylinder 10 by 7 by 10 inches.

Brown's reversing engine is fitted. It has a steam cylinder 25.5 and an oil cylinder 17.7 inches diameter with a stroke of 23.62 inches. The reversing shaft is carried in bearings secured to the columns. Besides the main reversing engine there is an auxiliary one, working by rack and pinion. It has a steam cylinder 7 inches diameter by 4.72 inches stroke.

There is a turning engine for each main engine. It has two cylinders 7.48 inches diameter by 7.87 inches stroke.

There is a bilge and a sanitary pump, worked from the forward end of the crank shaft. They have plungers 7.87 inches diameter and 11.8 inches stroke.

Steam pressure, pounds	213
Cylinders, H.P. (2), diameter, inches	36.61
1st I.P., diameter, inches	73.62
2d I.P., diameter, inches	103.94
L.P. (2), diameter, inches	106.30
Stroke of pistons, inches	72.83
Piston rods, H.P., diameter, inches	11.02
I.P. and L.P., diameter, inches	8.27
Tail rods, I.P. and L.P., diameter, inches	8.27
Connecting rod, length, feet	12.14
diameter, least, inches	10.43

Connecting rod, diameter, greatest, inches	12.79
Piston valves, H.P., diameter, top, inches	22.44
H.P., diameter, bottom, inches	22.05
1st I.P. (2), diameter, inches	28.35
2d I.P. (2), diameter, inches	39.37
Balance pistons, 1st I.P., diameter, inches	9.84
2d I.P. and L.P., diameter, inches	15.75
Valve stems, H.P., diameter, inches	4.33
I.P. and L.P., diameter, inches	5.12
Crosshead guides, width, inches	20.08
Reversing engine, steam cylinder, diameter, inches	25.59
oil cylinder, diameter, inches	17.72
stroke, diameter, inches	11.42
Crank shaft, diameter, inches	25
axial hole, inches	10.04
pins, diameter, inches	25.20
axial hole, inches	10.04
length, inches	29.92
webs, thickness, inches	16.54
width, inches	48.82
Length of forward section, feet	13.02
each of the other sections (3), feet	15.42
Distance between centers of two forward cranks, feet	11.48
two after cranks, feet	11.48
Nos. 2 and 3 cranks, f et	19.36
Weight of complete crank shaft, tons	100.55
Thrust shaft, diameter, inches	25
length, feet	17.85
number of collars	12
surface of collars, square inches	4,520
Line shaft, diameter, inches	23.62
Propeller shaft, diameter, inches	25.2
Total length of shafting each engine, feet	216.57

Condensers.—The condensers are cylindrical and are of brass, the shells formed of plates riveted together and to angle-iron stiffeners. There are four sections in the body of the condensers. The tube plates are of Muntz metal.

Diameter of condenser, external, feet	8.59
Thickness of shell, inch	.354
Length between tube plates, feet	20.68
Tubes, number in each condenser	5,320
diameter, inch	.75
length, feet	20.89
Tube plates, thickness, inches	1.10
Condensing surface, each condenser, square feet	20,452

The circulating water enters at the top and leaves at the bottom at the same end.

The auxiliary condenser is located in the port engine room.

Diameter, feet	3.51
Length, feet	5.97
Tubes, number	763
Cooling surface, square feet	892

Air pumps—There are two Blake twin air pumps for each engine.

Diameter of steam cylinders, inches	18
air cylinders, inches	44
Stroke, inches	24
Diameter of pump suction, inches	20

Circulating pumps.—There are two pumps for each engine, each worked by a compound engine so arranged that boiler-pressure may be used in both cylinders when pumping from the bilge. The suction pipes are connected so that either pump may be used on either condenser. There is no peculiarity about the pumps except that the bearings are outside the casing.

The principal data are—

Diameter of runners, inches	47.24
Revolutions per minute	150
Capacity per minute, gallons	18,000
Diameter of steam cylinders, inches	11 and 19.7
Stroke, inches	11.81
Diameter of suction and delivery pipes, inches	19.68

The delivery pipe from each pump of a pair goes direct to the condenser.

The auxiliary circulating pump is:

Diameter of runner, inches	19.2
Capacity per minute, gallons	650
Diameter of steam cylinder, inches	5.9
Stroke, inches	5.9
Diameter of suction and discharge pipes, inches	5.9

Screw propellers.—The screw propellers are four bladed, the blades being of bronze, the hub of cast steel, and the cap of cast iron.

Diameter, feet	22.31
Pitch, feet	36.08
Helicoidal area, square feet	139.83
Distance from center to center of hubs, feet	24.28
Center of hub above keel	12.47

Boilers.—The boilers are arranged in four watertight compartments, the two after ones occupying the space between frames 90 and 142½ (129.4 feet), and the two forward ones the space between frames 158 and 201½ (107 feet), the intervening space being used for a coal bunker. There are three double and one single-ended boiler in each boiler room, and one smoke-pipe for each set of boilers. There are three combustion chambers in each boiler, one for each wing furnace and one for the two lower furnaces for the single-ended boilers, and the same arrangement for the double-ended ones, except that the combustion chambers for the opposite furnaces are in common. The principal data are:

Steam pressure, pounds	213
Diameter each boiler, feet	16.57
Length double-ended boilers, feet	20.33
single-ended boilers, feet	11.15
Grate surface, each double, square feet	156.3
each single, square feet	78.15
total, square feet	2,188
Heating surface, each double, square feet	6,092.6
each single, square feet	3,089.3
total, square feet	85,468
Tubes, diameter of stay and plain, inches	2.75
stay, number at each end	182
thickness of 96, inch	.312
86, inch	.194
plain, number at each end	296
thickness, inch	.135
Furnaces, diameter, internal, inches	43.31
external, inches	47.24
thickness, inch	.708
Thickness of plates: shell, inches	1.456
tube-sheet, front, inch	.945
back, inch	.905
back-head, inch	.984
lower front-head, inch	.866
Longitudinal braces in steam space, diameter, inches	2.835
water space, diameter, inches	2.205

Weight of each double-ended boiler empty, with mountings, tons	96.425
single-ended boiler empty, with mountings, tons	58.05
Smoke pipes, number	4
diameter, feet	13.12
height above grates, feet	105

The main steam pipe from each group of boilers is of wrought iron 13.39 inches in diameter and .59 inch thick, the two pipes from the forward groups running on the port, and those from the after groups on the starboard side up to the engine-room bulkhead, where they unite in a wrought-iron pipe 17.72 inches diameter and .78 inch thick.

The forced draft is on the Howden system, and comprises four blowers for each group of boilers, two mounted on a common shaft operated by a compound engine.

Diameter of cylinders, inches	7 and 12
Stroke, inches	7
Fans, diameter, inches	84
width at tips, inches	20
hub, inches	26.5

There is in each boiler room an ash ejector, besides which there are on the main deck four ash-hoist engines, each 23.62 inches diameter and 7.87 inches stroke.

Feed pumps.—There are four pairs of Weir pumps (8 pumps) arranged along the forward bulkhead of the engine rooms and used as main feed pumps; each has a steam cylinder 19 inches and a water cylinder 14 inches diameter, with a common stroke of 32 inches. Besides these, there is in each boiler room a Blake duplex auxiliary feed pump 12 by 8½ by 12 inches.

The suction pipes for the main feed pumps are 9 inches in diameter, and the main feed pipe for two groups of boilers 7 inches. The auxiliary feed pipe is also 7 inches in diameter.

In addition to these pumps there are the following:

In each engine room a Blake duplex pump, 12 by 7½ by 12 inches, for port service; one sanitary pump and one bilge pump of the Blake type, each 12 by 12 by 16 inches; one Worthington pump, 6 by 4 by 6 inches, for bath purposes, and two Worthington pumps, 5½ by 3½ by 5 inches, for fresh-water service. In the for-

ward boiler room, a duplex ballast pump, 11 by 12 by 12 inches.

There are the usual feed-water heaters and filters, and two evaporators, with a rated capacity of 20,000 gallons a day.

The best voyages of the *Deutschland* have been 5 days, 12 hours, 29 minutes from Cherbourg to New York, and 5 days, 7 hours, 48 minutes from New York to Plymouth, with the following results:

	Westward.	Eastward.
Mean speed, knots	23.02	23.36
Best day's run	584	549
Coal per day, tons	561	572
Revolutions per minute	77	77.4
I.H.P.	35,988	36,940

The two steamers building by the Eastern Shipbuilding Company, at New London, Conn., for the Great Northern Steamship Company, and intended for the Pacific trade, will be the largest steamers ever built in this country. Their dimensions are:

Length, feet	630
Beam, feet	73.5
Depth, feet	55.67
Gross tonnage	21,000
Deadweight capacity, tons	20,000
Bunker capacity, tons	4,500
Displacement, tons	33,000
I.H.P.	8,000
Speed, knots	13

They are designed especially for freight, but will have accommodations for 200 first, 100 second, 200 third-class and for about 1,000 steerage passengers.

In outward appearance they have four pole masts and one smoke pipe.

The engines are twin-screw triple-expansion, with cylinders 34, 57 and 96 inches diameter by 54 inches stroke, and will be built by the Midvale Steel Company. Steam will be furnished by sixteen Niclausse boilers, working under a pressure of 250 pounds, and containing 1,000 square feet of grate, and about 45,000 square feet of heating surface.

It is expected that these steamers will be completed by the Summer of 1902. Their cost will be about $2,500,000 each.

Kronprinz Wilhelm.—There was launched from the Vulcan Works, Stettin, on the 30th of March, a steamer built to the order of the North German Lloyd Company for their Atlantic line. She is about 15 feet longer than the *Kaiser Wilhelm der Grosse*, but otherwise of practically the same dimensions, and is considerably smaller than the *Deutschland*. The dimensions of the three ships, all of which were built by the Vulcan Company, are taken from "Engineering":

	Kronprinz Wilhelm.	*K. W. der Grosse.*	*Deutschland.*
Length over all, feet	*663.33	648.62	684
Breadth, feet	*66	66	67
Depth, molded	*43	43	44
Gross tonnage	*14,800	14,349	16,502
Draught, normal, feet	28.5	28	29
Displacement, tons	*21,280	20,880	23,620

*"Le Yacht" gives these figures as 665.04, 65.65, 42.68, 15,000 and 21,000.

The contract speed is 22 knots. The poop is 115 feet long, the bridge house 374 feet, and the forecastle 115 feet. Above the poop and bridge houses there is a promenade deck 508 feet long; and above this a sun deck of equal length. The double bottom contains twenty-four compartments, while the interior of the ship is divided by fifteen transverse bulkheads reaching to the upper deck and thus far above the load-water line, with a longitudinal bulkhead between the engines. All the bulkheads have been made sufficiently strong to stand the pressure due to any one of them being filled while the adjoining compartment is entirely empty.

As to the passenger accommodation, there are 214 cabins fitted for over 600 first-class passengers, 102 cabins for 350 second-class passengers, while on the lower decks comfortable quarters are provided for over 700 third-class passengers. The crew will number about 525. In addition to the ordinary state rooms mentioned, there are eight luxurious cabins and four suits of rooms fitted for special passengers. These suits include a living room, bed room and a bath room. The dining room, which occupies the central part of the ship, will be artistically decorated, and will have accommodation for 414 passengers; the

reading room, drawing room and smoking room are fitted on the bridge deck, and their chief characteristic is the great height of ceiling. The second-class passengers have a dining room, smoking room and a drawing room located in the after part of the ship.

The propelling engines of the ship are of the quadruple-expansion type, working four cranks balanced on the Schlick system, the total indicated horsepower anticipated in the design being 30,000 with the boilers working at 213 pounds. There are twelve double-ended and four single-ended boilers, as in the *Deutschland*, equally divided in four groups, so that in each compartment there are three double and one single-ended boiler, with a funnel for each battery, 113 feet in height above the keel. The total heating surface is 93,649 square feet, and the grate area, 2,702 square feet. There are four dynamos, three in the after part of the engine room, between the two lines of shafting, and one on the main deck, so placed that it will be available even in the event of the engine room being flooded. The dynamos deliver a current of 100 volts and 825 ampères.

Prinzessin Victoria-Luise.—Messrs. Blohm and Voss, of Hamburg, last year built for the Hamburg-American Line a vessel solely for first-class passengers, and intended for pleasure cruises or excursions, being, in fact, as she is, in outward appearance, a very large yacht.

A comprehensive description of this vessel was given on page 323 of the last number of the JOURNAL, but inasmuch as more complete data are now available, the following description, translated from "Zeitschrift des Vereines Deutscher Ingenieure," is given as containing all available data.

She has two pole masts, one well forward and the other well aft, with two smoke pipes between. There are two cargo booms on the foremast and three on the mainmast, of which four of 2 tons' capacity are of wood, and the remaining one, of 7 tons, of steel.

Her principal characteristics are:

Length, extreme, feet	446 2
on water line, feet	400
Breadth, extreme, feet	47

Depth, feet	29.76
Deadweight capacity, tons	2,032
Bunker capacity, tons	1,200
Gross tonnage	4,409
Draught, mean, feet	16.5
Displacement, tons	5,650
Speed, knots	16
I.H.P.	4,000

She has accommodations for 200 passengers, and is fitted up in elegant style throughout, having all the accommodations of an Atlantic liner.

The contract required that she maintain a speed of 15 knots for eight consecutive hours, during which the I.H.P. should not fall below 3,600; and that on a mean draught of 16.5 feet, her mean speed across the Atlantic should be 14 knots.

The main engines are twin-screw, quadruple-expansion, and are in a common compartment. The H.P. cylinder is forward, the first I.P. aft, and the second I.P. and the L.P. between them, the L.P. being the forward one. The H.P. and the two I.P. cylinders have piston valves, and the L.P. a slide valve. The crank shaft is in four sections, and the cranks at angles of 65, 94, 107 and 94 degrees with each other. The condensers are on the outboard side of each engine, and carry the back columns.

There are four single-ended boilers working under forced draft on the Howden system. They are placed in two compartments separated by a coal bunker, through which there is a tunnel for the passage of pipes. The arrangement of the blowers and air ducts is such that either set of boilers may be worked under forced draft.

The principal dimensions of the machinery are—

Steam pressure, pounds	213
Cylinders, H.P., diameter, inches	19
1st I.P., diameter, inches	27.56
2d I.P., diameter, inches	39.37
L.P., diameter, inches	57.08
Stroke, inches	36.22
Revolutions, estimated	120
Center to center of forward pair of cylinders, feet	5.64
after pair of cylinders, feet	5.64

Center to center of middle cylinders, feet	9.84
Crank shaft, diameter, inches	10.63
Thrust shaft, diameter, inches	10.95
rings, number	6
Tunnel shaft, diameter, inches	10.39
Air pumps, Blake, twin, number	1
diameter, inches	20
stroke, inches	12
Steam cylinders, diameter, inches	9
Circulating pump, capacity at 160 revolutions, gallons	7,500
Boilers, diameter, feet	14.44
length, feet	11.68
grate surface, total square feet	230
heating surface, total square feet	9,688
tubes, each boiler, diameter, inches	2.75
number, stay	174
plain	184
thickness, stay, inch	.315
plain, inch	.157
Furnaces, number in each boiler	3
diameter, greatest, inches	45.3
least, inches	41.3
Shell plates, thickness, inches	1.50
Front and back heads, thickness, inches	1.02
Fans, diameter, inches	75
Dynamo engines, number	3
capacity, total ampères	820
volts	100

She is provided with distilling apparatus, an ice machine, feed-water heaters and evaporators. The main feed pumps are of the Weir type.

Indicator diagrams taken on her first voyage showed 4,200 I.H.P. with 123 revolutions per minute.

The double bottom is utilized as ballast tanks, reserve feed tanks, and drinking-water tanks, the total capacity of the latter in the ship being 67,200 U. S. gallons.

The crew numbers 156, including 5 officers, a boatswain, doctor, 2 pursers, 62 servants and cooks, 14 engineers, assistants and oilers, and 27 firemen.

Haverford.—A twin-screw steamer, building for the International Navigation Company by Messrs. John Brown & Co., Clydebank, Scotland, will soon be launched.

The *Haverford* is a four-masted steamer of the type called "intermediate," which has of late years become so popular on the Atlantic. That is to say, she is designed neither for rapid passenger service exclusively, nor for cargo carrying only, but for combined passenger and cargo traffic on the most approved principles. One essential of this class of boat is that there shall be sufficient speed to suit all passengers who prefer comfort to the headlong rates of the racing liners. The *Haverford*, therefore does not aim at a speed of more than 17 to 18 knots.

Her dimensions are:

Length between perpendiculars, feet	530
Breadth, feet	59
Depth, molded, feet	39
Gross tonnage, tons	11,500

She is built to Lloyds' highest classification, and beyond, for she is specially strengthened against the rough weather of the North Atlantic. Internally she is divided into ten watertight compartments in such a way that she will float even with two of these compartments flooded. The enormous bunkers are grouped around the boilers, for which they will serve as a sort of armor shielding should the boat ever be taken up for war service, and the propeller shafts are enclosed in the ship's framework and plating to their outer ends. Still further to insure the safety of the ship and to secure sufficient immersion of the screws when she is running light, deep ballast tanks are placed in two of the holds extending to the lower deck. These tanks, along with the usual provision in the cellular double bottom, afford storage for about 4,000 tons of water ballast.

The whole of the interior of the ship below the upper deck (except what is occupied by the machinery, boilers, bunkers and store rooms) is set apart for cargo, and insulated chambers are provided for the conveyance of refrigerated goods. For the working of the huge cargo, seven hatches are furnished with ten powerful winches and derricks, the latter being attached to each of the four masts. An unusually massive windlass is placed on the topgallant forecastle to work the anchors, and there are also two extra-sized warping winches. Both windlass and winches

are of American make. The ship is fitted with docking and steering telegraphs, and the steam-steering gear is placed under the poop deck.

And now as to passenger accommodation: Amidships on the upper deck is a long bridge accommodating 500 third-class passengers. In the forward portion are portable berths in large rooms on both sides, with dining tables down the center. These portable berths take in about 300 persons. In the after portion are a series of state rooms to hold four or six passengers each—those on the port side for men, and those on the starboard side for women, or for married couples with families. The dining-room outfit is much superior to that provided usually for third-class passengers. The provision of baths, lavatories, sanitary accommodation, etc., is ample and excellent and conveniently arranged for both sexes. Two companions lead from the third-class quarters to the promenade deck, where there is a commodious smoking room. Above the shelter deck is the cabin accommodation, located in a bridge house 150 feet long and the whole width of the ship. Here are large and airy state rooms for 150 first-class passengers. At the forward end is the dining saloon, seated for 112 persons. It is paneled in light oak and tastefully upholstered and decorated, one novel feature being the grouping of the side ports in pairs.

Abaft this bridge house are the quarters of the engineering staff, and above is the promenade for the cabin passengers. At the after end of this promenade deck are the captain's room and officers' quarters, and at the forward end is the ladies' boudoir. Abreast of the engine casing is a lobby, giving entrance to a large and very comfortable smoking room on the starboard side and to the library on the port side. Above these houses are the boat decks, wheel house and navigating bridge, the latter protected by a steel bulwark. Eighteen boats are carried (including sixteen life boats), and life belts are stowed in every state room.

For propulsion the *Haverford* has two main sets of vertical, triple-expansion engines of the inverted marine type, each cylinder driving a separate crank. Each high-pressure cylinder is 29

inches diameter, each intermediate is 46½ inches diameter and each low-pressure cylinder is 75 inches diameter. The stroke is 4 feet 3 inches, and all cylinders are fitted with liners. For the high-pressure cylinders the slide valves are of the piston type, and for the intermediate and low-pressure cylinders they are of the flat-faced type. The valve gear is of the usual double-eccentric double-bar link-motion type. The air pumps are driven by the levers off the crosshead of the intermediate cylinders. To each set of engines is fitted a direct-acting, steam-reversing engine, and the levers of the reversing shaft are fitted with screw gear to admit of the adjustment of cut-off being made in one cylinder independently of any of the other cylinders. The shafting is of steel, and each crank shaft is of the built-up type in three interchangeable pieces. The main bearings, thrust shoes and tunnel blocks are lined with white metal. The propellers are four-bladed, with bosses of cast iron and blades of manganese-bronze. The auxiliary machinery consists of two centrifugal pumps for circulating the water through the main condensers; two vertical simple pumps, with float gear, capable of feeding the boilers when working at full power; two ballast pumps, one sanitary pump, one fresh water pump and a donkey boiler-feed pump. There is also a feed heater and filter and a very complete distilling plant, especially designed with a view to cattle service. To each engine is fitted an Aspinall governor. For steam generation there are two double-ended and two single-ended boilers working at 160 pounds pressure under natural draft.—"Marine Review."

Apache.—One of two sister ships building by the Cramp Company for the Clyde Line, and intended for service between New York, Charleston and Jacksonville, was launched on the 30th of March.

She is 310 feet long, 46 feet beam and 31 feet deep with a cargo capacity of 3,000 tons. She has accommodations for over 200 passengers.

Her engine has cylinders 25, 43 and 70 inches diameter by 36 inches stroke. Steam is furnished by two boilers 16 feet 6 inches diameter, and 10 feet 5 inches long.

The second vessel, the *Arapahoe*, was launched May 18th.

Artemisia.—This steamer, built by Palmer's Shipbuilding Company for the Hamburg-American Line, recently completed her trial with satisfactory results, her mean speed being 13¾ knots.

She has four masts, rigged fore-and-aft, and is of the three-decked type, with two steel decks laid all fore-and-aft, and has a shelter deck specially strengthened for the Atlantic trade, extending over the whole length, and above this is a bridge deck 130 feet long. A cellular double bottom is fitted fore and aft for water ballast. Water ballast is also arranged to be carried in a deep-cargo tank and in the after peak, giving her a total water-ballast capacity of over 2,000 tons. She is divided into nine watertight compartments, by means of eight steel bulkheads, all of which extend to the upper deck. A most complete system of ventilation has been arranged to ensure the safe carriage of grain or other cargoes. The vessel has ten hatches, sixteen powerful steam winches and twenty-four derricks, provided for the rapid loading and discharging of cargoes. A powerful steam windlass is fitted forward for working the cables, and a combined hand and steam steering gear of special design is fitted in a large steel wheelhouse on the after end of the shelter deck.

Her dimensions are:

Length between perpendiculars, feet	452
Breadth, feet	52
Depth, feet	31
Cargo capacity, tons	8,300

The engines are of the inverted triple-expansion type, having cylinders 30, 50 and 81½ inches diameter and 54 inches stroke, steam being supplied by three double-ended boilers 14 feet 6 inches diameter and 17 feet 6 inches long, with a working pressure of 180 pounds. The propeller is of manganese-bronze, and all the auxiliary machinery is of the most modern type. During the trial the engines worked in a highly satisfactory manner at 68 revolutions per minute.

Denver.—A single-screw steamer, built by the Harlan and Hollingsworth Company for the Mallory Line, was launched on the 4th of April. Her dimensions are:

Length over all, feet	386
Beam, molded, feet	48
Depth from awning deck, feet	35
from main deck, feet	26
from lower deck, feet	16
Draught, feet	19
Tons cargo at above draught	3,000
Speed, knots	15.5

She will have accommodations for 58 first-class and 78 steerage passengers.

Her engines will have cylinders 33½, 54 and 87 inches diameter by 54-inches stroke, working with a pressure of 180 pounds. The boilers, four in number, are 16 feet 3 inches diameter and 11 feet 6 inches long, each with four Morison suspension furnaces 40 inches inside diameter. They are fitted with Howden's forced draft.

East Point.—A single-screw steamer built by J. L. Thompson and Sons, Sunderland, England, for the Norfolk and North American Shipping Company. She is intended for service between Philadelphia and London, and to carry general cargoes and cattle. Her dimensions are—

Length, feet	405
Beam, feet	51 5
Depth, feet	30.5
Cargo capacity, tons	7,750
Gross tonnage	10,000

She has a two-masted schooner rig with telescopic topmasts.

The engine is of 2,300 I.H.P., with cylinders 25, 43 and 74 inches diameter and 48 inches stroke. The boilers are three in number, and work under a pressure of 200 pounds.

Donnacona.—This is a single screw-steamer built in England for the Hamilton and Fort William Navigation Company, and is intended for service on the Great Lakes. She is specially designed for carrying coal, grain and ore between Lake Superior and Hamilton and Montreal, and, loaded to a draught of 14 feet, will be able to navigate the canal system of Canada, which, by reason of recent improvements, now affords sufficient depth of water to permit of direct navigation for vessels of that size be-

tween the lakes and the open sea. She can carry 2,650 tons on a draught of 16 feet 5 inches.

Her dimensions are:

Length, feet	255
Beam, feet and inches	42-6
Depth, feet and inches	23-8
Speed, knots, nearly	10

She has triple-expansion engines of about 1,000 I.H.P., with cylinders 18½, 30½ and 51 inches diameter and 36 inches stroke. Steam is furnished by one boiler working under a pressure of 170 pounds.

Northwestern, Northward, Northeastern and **Northtown.**—Four steamers built by the Chicago Shipbuilding Company for the Northwestern Transportation Company, and intended for transatlantic service, loading at Chicago and delivering at Liverpool, Hamburg and London. They are of the following dimensions:

Length over all, feet	256
on keel, feet	252
Breadth, molded, feet	42
Depth, molded, feet	26.5
Draught, load, feet	20
Gross tonnage	2,900

As only 14 feet can be carried through the Welland Canal, the loading of these vessels is completed at Montreal.

The machinery, which is placed well aft, consists of a triple-expansion engine with cylinders 20, 33 and 54 inches diameter, and 40 inches stroke, and two Scotch boilers 12 feet 9 inches diameter and 11 feet 6 inches long.

A number of other steamers, of practically the same size, are also under construction for like service.

New York.—An explosion of the ammonia condenser of the refrigerating apparatus on board the steamship *New York*, of the American Line, on March 14, resulted in the death of two men—a steerage passenger and a steward. Many persons were more or less seriously injured by the spreading of the ammonia fumes through the steerage quarters on the saloon deck. On the follow-

ing day the tail shaft of the port engine broke in two close to the screw. A smooth sea prevailed at the time, allowing the screw to be secured by steel cables, and the remainder of the journey to New York was made at a speed of 14 knots with the starboard engine. This is the third accident of the kind that has happened to the *New York* within less than a year.

She has now been taken off the line, and will go to Cramp's to have her old machinery removed and new machinery substituted, besides having many alterations made in her hull and internal arrangements.

Nicomedia.—A side-tank steamer, built by Messrs. William Gray and Company, Hartlepool, England, for the Hamburg-American Line. Her dimensions are:

Length over all, feet	398
Breadth, feet	52
Depth, feet	28.33
Cargo capacity, tons	7,150

A cellular double bottom extends throughout, and the after peak also takes water ballast, whilst the side tanks contain an additional 850 tons, giving over 1,900 tons water ballast in all. These side tanks extend through the main and after holds and engine room for a length of 217 feet, in way of which the ship has double sides, adding greatly to her strength and safety.

The machinery consists of a set of triple-expansion engines of over 1,600 horsepower, having cylinders 27 inches, 43 inches and 72 inches diameter, by 45 inches stroke, with three main boilers working at a pressure of 180 pounds per square inch, all by the Central Marine Engine Works of the builders.

Port Antonio.—There was launched from the yard of Sir Raylton Dixon & Company, Middlesbrough, England, March 12th, a twin-screw steamer for Messrs. Elder, Dempster & Company, and intended for trade between England and Jamaica, Parliament having recently voted a subsidy of £40,000 a year toward the development of the West India trade.

She is 382 feet long, 46 feet 6 inches beam, and has a depth of 32 feet 7½ inches. Her speed is intended to be 15 knots at sea. She has accommodation for 100 first-class and 50 second-

class passengers, who will be accommodated in most luxurious and well-ventilated apartments. The first-class dining saloon is arranged at the forward end of the large deckhouse, the walls of which will be of polished marble, with woodwork of dark mahogany upholstered in rich tapestries and lighted by electric light. The holds will be specially lined and insulated for carrying fruit, the temperature being regulated by Hall's patent cold-air system of refrigeration, capable of maintaining an equable low temperature in the holds, which will contain 20,000 bunches of bananas. Port doors have been provided for the rapid loading and discharging of ripe fruit. Large, powerful steam winches will be fitted with discharging gear of the latest and most approved type.

The machinery is by Messrs. Richardson, Westgarth & Company, and consists of twin-screw engines with boilers working under forced draft on the Howden system. The principal dimensions are:

Indicated horsepower	4,800
Steam pressure, pounds	180
Cylinders, H.P., diameter, inches	24
I.P., diameter, inches	38
L.P., diameter, inches	64
Stroke, inches	45
Revolutions per minute	90
Piston rods, diameter, inches	6½
Crank shaft, diameter, inches	12¾
pins, diameter, inches	13
length, inches	15
Thrust shaft, diameter, inches	12¾
Line shaft, diameter, inches	12⅛
Boilers, number	4
diameter, feet	16
length, feet	12
tubes, No. 8 B.W.G., diameter, inches	2½
length, feet and inches	8–2
Heating surface, square feet	12,000
Fan for forced draft, diameter, inches	102
Smoke pipe, diameter, feet	10

The high-pressure valves are of the piston type, and the others slides. The condenser is a separate casting from the engine

framing, and is placed outboard of the back columns. The air pumps are of the Edwards patent.

Another vessel, the *Port Royal*, a duplicate in all respects of the *Port Antonio*, has been built by the same firm for the same line.

Port Maria.—Another vessel for the same line as the two preceding ones was launched in December last from the works of Ramage and Ferguson, Leith, Scotland, and had a successful trial on the 9th of March. She is a single-screw vessel, 320 feet long, 40 feet beam and 28 feet depth of hold, and has been designed for a speed of 15 knots.

She has accommodations for first and second-class passengers. One notable departure from recognized procedure has been carried out in the scheme of the first-class saloon, which has its tables arranged in four bays on each side of the center of the room, each table accommodating a party of six persons. The chief feature of the cargo holds is the elaborate arrangement made for bringing fresh fruit across the seas in best condition.

Her engine is of 4,200 I.H.P., and has cylinders 31, 50 and 80 inches diameter and 48 inches stroke. There are four boilers working at a pressure of 180 pounds per square inch, with Howden's forced draft.

A duplicate vessel, the *Port Morant*, has been built for the same line by Alexander Stephen and Son. Her engine cylinders are of the same diameter as those of the *Port Maria*, but of 45 inches stroke.

Rio de Janeiro.—This steamer belonging to the Pacific Mail Steamship Company, and running between San Francisco and Yokohama, struck a rock and foundered at the Golden Gate at the entrance to the harbor of San Francisco on February 22. Of the 207 people on board, 128 were lost. The accident occurred during a dense fog, and the ship sank within a few minutes in 36 fathoms of water. The *Rio de Janeiro* was launched in 1878, and was not provided with watertight bulkheads, which accounts for her rapid sinking.

Saale.—The Townsend & Downey Shipbuilding and Repair Company, of New York, has been awarded the contract to rebuild and equip the steamship *Saale* with new engines, shafting,

etc. The *Saale* is one of the ships of the North German Lloyd Line partially destroyed by the great fire in Hoboken last year. She was recently purchased by Lewis Luckenbach, of New York, and is now to be rebuilt and operated as a cargo ship.

She will be equipped with a triple-expansion engine having cylinders 29, 46 and 70 inches diameter and 48 inches stroke.

The time required for the extensive alterations and repairs will be about five months, and the cost of altering her about $200,000.—" Marine Journal."

Zeeland.—Messrs. John Brown and Company, Clydebank, Scotland, recently completed this steamer for the International Navigation Company for their New York-Antwerp line. She is a duplicate of the *Vaderland*, mentioned on page 846 of Volume XII of the JOURNAL, and is of the following dimensions:

Length between perpendiculars, feet	560
Breadth, molded, feet	60
Depth, molded, feet	42
Gross tonnage	12,000

She has eleven transverse bulkheads, and has been specially strengthened for the transatlantic service. There is space for about 11,000 tons of cargo, and tanks are provided for upwards of 200 tons of fresh water. The vessel will carry altogether 342 first-class, 194 second-class and 626 third-class and steerage, while the ship's company will number about 253, giving a total of 1,415 people to be provided for. The dining room is on the main deck amidships between the funnels, and extends the full breadth of the vessel. It can seat about 200 passengers. The drawing room, painted in white enamel, and 36 feet in width, is situated at the forward end of a long deck house on the promenade deck. The main deck is given up to passenger accommodation.

The engines are of the twin-screw quadruple-expansion type, with cylinders 31, 44, 62 and 88 inches diameter by 54 inches stroke, and work with a boiler pressure of 200 pounds, steam being supplied by eight single-ended boilers. The boilers have four furnaces each, and are fitted with induced draft on the Ellis and Eaves system, there being one Sturtevant fan 90 inches

diameter for each boiler. The tubes are Serve, 3¼ inches diameter. The crank and thrust shafts are 17½ and the tunnel shaft 16½ inches in diameter. The air pumps are of the Edwards type, 29½ inches in diameter and 27 inches stroke.

The *Zeeland* had a successful trial on the 5th of April, maintaining a speed of 17.3 knots for twelve hours.

YACHTS.

Constitution.—This is the name that has been selected for the cup defender built by the Herreshoffs. The following description is from the "Scientific American," which states that it is authentic:

The *Constitution* is a high-powered *Columbia*, with the same sheer plan, the same draught, a lighter hull, more lead, with exactly a foot more beam (not two feet, as currently reported), with less dead rise, a flatter floor and a harder bilge. As the result of these combined improvements, all looking to the one object of increased power, she carries about 10 per cent., or about 1,300 square feet, more sail than *Columbia*. Her dimensions are as follows:

Length over all, feet and inches	132– 6
on water line at normal draught, feet and inches	89– 9
Beam, feet and inches	25– 2½
Normal draught, feet and inches	19–10

Principles of Design.—Other things being equal, the fundamental object aimed at in the design of a 90-foot racing yacht is power, or the ability to carry a maximum amount of sail. This may be secured by changes of form, or by reduction or transposition of weights, or both. Increased power, due to form, is gained by increase of beam, by flattening the floor and "hardening" or filling out the bilges, thereby raising the center of buoyancy and placing the body of the boat more upon the surface of the water. Power due to form, however, is gained at the expense of sweetness of lines and ease of propulsion; hence, the genius of the designer is shown in finding that happy mean which gives a maximum power with a minimum hardness of form. Thus, comparing the last three Herreshoff boats, *Defender* presents in her midship section the sweetest and most beautiful form ever seen in an American 90-footer, the bilges rounding in to the

reverse curve of the garboards with the unbroken sweep of a letter S. In *Columbia* the floor is flatter, the beam is increased, the bilge hardens and the garboard curve is reduced. In *Constitution* the development has been pushed still further; there is even less dead rise, there is a distinctly straight line in the floor and the bilge is still harder than that of *Columbia*. The results of this development, in terms of sail area, are seen in the respective figures of 12,640 square feet for *Defender*, 13,125 for *Columbia* and 14,400 for *Constitution*.

Not all of this increased power is to be attributed, however, to form. Much of it is due to improved methods of construction, by which the same strength of spars and hull is secured with the use of less material. In a yacht of a given displacement every pound of weight that can be taken out of the rigging, spars or hull may be placed in the lead keel with a consequent increase in sail-carrying power. Thus we find that the ballast (that is, the lead keel and the loose pig lead for trimming of the vessel) has gone up from 85 tons in *Defender* to 90 tons in *Columbia*, and as high as 93 tons in *Constitution*. *Columbia* is a larger boat than *Defender* and probably is slightly heavier in construction; but as compared with *Columbia*, the new boat, in spite of her greater beam and increased lead, will be of about the same displacement, a feat of construction for which the greatest credit is due to the designer.

Radical Change in Construction.—The considerable lightening of the hull of *Constitution* (which, be it remembered, has been accompanied by a decided gain in strength) has been secured by a radical change in the method of framing. The usual system in yacht construction is to use shallow transverse frames, a few inches in depth, at intervals of 20 to 22 inches, throughout the whole length of the yacht. This is the system adopted in *Independence*. It is this framing that holds the hull to form, by resisting the transverse bending and crushing stresses; while the longitudinal stresses are taken up by the plating, assisted by two or four lines of stringers, as the case may be, by far the greater part of the longitudinal strains, however, fall upon the plating itself. Hence the latter must be made of greater weight than is

actually necessary to enable it to act as the mere skin clothing of the frames. Herreshoff's innovation consists in running the framing of the yacht in both directions, using deep belt frames of an I-beam section for the transverse system of framing, and associating them with a system of longitudinal T-bar and angle-iron framing, which serves at once to take up a large proportion of the longitudinal strains which ordinarily fall upon the plating, and so enables the weight of this plating to be very materially reduced. The transverse belt frames and the longitudinal framing are so arranged with regard to the width and lengths of the plating that the butt joints meet upon the frames, and the seams follow the longitudinal T-irons, thus doing away altogether with the weight of the washers and liners necessitated in riveting up a boat built in the conventional way.

Judged from an engineering standpoint, this is a far more scientific distribution of the material to meet the special strains to which the hull of a yacht is subjected, particularly in a seaway. Just how great is the saving in weight is shown by the fact that although the superficial area of the Tobin bronze plating on *Constitution* is greater than the superficial area of the bronze on *Independence*, the sheer strake in the latter being of steel, the total weight of the bronze plating actually laid on the Boston boat is a fraction under 30 tons, while the total weight of the plating in *Constitution* is slightly under 22 tons. Moreover, it must be remembered that this difference of 8 tons may be put into the keel without calling for a pound more of displacement, or the increase of a single square foot of wetted surface. This is a clear gain due to good engineering; and surely the yacht designer who would dare to use $\frac{6}{32}$-inch plating on the topsides of a 90-footer is entitled to all the gain in power and speed that are coming to him. Just here it may be well to state that no little of the credit of these successful results is due to that remarkable material Tobin bronze (the invention of a United States naval officer whose name it bears) which has come to be looked upon as an indispensable material for the plating of our American cup defenders. Not only does it take on a wonderfully smooth polish, but it preserves it indefinitely; while

it has the further invaluable quality of showing a tensile strength in the test specimens that is only a few pounds under 40 tons to the square inch.

Structural details.—The transverse belt frames, which are spaced 6 feet 8 inches apart, extend entirely around the hull and do duty at once as frames, floor plates, and deck beams. They are of I-beam section, the web from $\frac{5}{40}$ to $\frac{6}{40}$ of an inch thick and 15 inches deep amidships, the depth decreasing toward the ends, with flanges formed each of a pair of $1\frac{1}{2}$ by $1\frac{1}{2}$-inch angles. The belts are built up in sections with a $2\frac{1}{4}$-inch lap at the joints riveted with a double row of $\frac{5}{8}$ rivets. These beams, by virtue of their great depth, provide far greater stiffness than an equal weight of the shallow 4-inch bulb angles which are used in the conventional type of construction. *Constitution* is not the first yacht to carry these frames, as they were used experimentally in last season's 70-footers. Mr. Herreshoff has profited by that experiment; for in a jump of a sea off Newport the frames buckled, the inner flanges springing out of line; hence the presence of diagonal braces of $1\frac{1}{8}$-inch pipe which extend, in pairs, from the longitudinal T-irons to the inner flanges of the belts. These struts, moreover, afford stiffness to the longitudinal framing of the hull and deck.

The longitudinal framing consists of alternate $4\frac{1}{2}$ by $4\frac{1}{2}$ T-bars and 3 by 2 bulb angles. The T-bars follow the seams of the plating, which, in general, is 48 inches wide, and the angles are spaced midway between the T-bars. The belt frames are cut to allow these longitudinal frames to pass through, and the latter extend in unbroken lines from stem to stern, the ends of the T-bars being jointed with a U-iron splice, riveted to head and web of the bar, while the bulb angles are placed back to back, at the joints, and riveted. These longitudinal members being continuous and well riveted to the plating, it will be seen that they not merely keep the plating to shape, but also take a large share of the longitudinal stresses. Calculation of the weights of a given area of framing in *Constitution* and *Independence* shows that there is not much weight saved in the framing alone, but it must be remembered that, weight for weight, it is a much stronger con-

struction. The saving is in the weight of the plating, which Mr. Herreshoff has lightened out to the extent, as we have seen, of eight tons, as compared with *Independence*. Amidships there are seven strakes of plating. Commencing at the sheer strake, the thicknesses are $\frac{6}{32}$, $\frac{6}{32}$, $\frac{6}{32}$, $\frac{7}{32}$, $\frac{7}{32}$, $\frac{7}{32}$ and $\frac{8}{32}$ inch. The first four strakes, to the top of the garboard strake, have flush seams; below this they are lap-jointed. The sheer strake extends above the deck line and is riveted to a 2 by 2 bulbed angle, whose head forms the rail of the boat.

The fin and lead bulb.—From station 28 to station 50 the belt frames are carried down into the fin and riveted to the keel plate, which is a Tobin bronze casting, $\frac{1}{2}$ inch thick by 18 inches wide, with 4-inch side flanges and transverse flanges at every frame station. At the three frame stations in the fin, intermediate between each belt-frame floor plate, is an angle-iron frame. Of these the center frame is a $1\frac{3}{4}$ by $1\frac{3}{4}$ plain angle, and the other two are 1 by 3 bulb angles. Here, again, Herreshoff has made a considerable saving of weight, for, instead of running the floor plates down to the keel, the frames are tied together merely by a 12-inch keel-plate and a 12-inch floor-plate, with a $1\frac{3}{4}$-inch square tie rod midway between them. These floor plates commence at station 11 and extend aft to station 63. The framed structure of the fin terminates, as we have seen, in a half-inch bronze keel plate, and below this plate the 95-ton belt of lead is hung in the following manner: First, the lowest strake of the bronze plating is extended down to overlap the lead by 20 inches, the latter being rabbetted out to receive it. Through these plates 824 bronze tap screws, $\frac{5}{8}$ by 6 inches, are screwed into the lead, 412 on each side. The keel is further supported by thirty-seven 1 by 10-inch vertical lag screws, which are screwed through the keel plate into the lead. If anyone cares to figure out the total section of the bronze bolts thus employed, he will find that there is an ample amount of holding strength, even should the *Constitution* experience a knock down in a short, jumpy sea, when the dynamic bending moment at the junction of the keel and lead might easily rise to a total of 400 or 500 foot-tons.

The mast step.—To provide the requisite strength at the mast

step (which, by the way, is placed 20 inches further aft than *Columbia's* mast) an extra belt frame is introduced, there being a belt frame at stations, 28, 30 and 32. The web of the frames is also increased to $\frac{7}{40}$ of an inch. The step is formed by a combination of these frames with a deep keelson of $\frac{7}{16}$-inch steel worked intercostally between the frames, from station 24 to station 36, the keel plate being increased to $\frac{5}{8}$ of an inch in thickness beneath the mast and for the full length of the mast step. The keelson increases in depth from frame 24 to frame 28, where it reaches a maximum of 4 feet 6 inches, which depth it holds from frame 28 to frame 32. From frame 32 it decreases in depth until it terminates at frame 36. The floor-plate portions of the frames 28, 30 and 32 carry the same depth as the keel plate. A $\frac{5}{8}$ inch, double cover plate closes in the mast step, and below the cover plate extends a deep, hollow cone of $\frac{5}{8}$-inch plating, which is riveted to the cover plate and the keelson. The upper flange of the cone consists of two $1\frac{1}{2}$-inch angles, the outside diameter of the ring, formed by these flanges, being just 24 inches. The bottom of the steel mast will have riveted around it a $1\frac{1}{2}$-inch angle iron, with an outside diameter of 24 inches, and when the mast is in place it will be bolted down upon the cone by bolts which will pass through the ring on the mast and be made fast by nuts below the cone ring. It is 6 feet 10 inches from the top of the deck, and on each side of the mast ring at the deck, intercostal plates are worked in between the belt frames. The mast framing at the deck is stiffened against fore-and-aft racking strains by a trussing of hollow steel tubing, which extends in a fore-and aft plane from the deck beams to the cover plate of the keelson. Three-inch tubular bilge struts extend from all the belt frames at the bilge to the same frames at the deck; but in the wake of the mast these struts are moved in to further assist in bracing the mast ring and mast step construction. The whole design is entirely novel, and shows the characteristic resourcefulness of the Bristol designer. It is extremely stiff and strong and gives evidence that Herreshoff has learned the lesson of the buckled mast steps with which he was troubled in previous defenders. In one of these, a step which had a cal-

culated resistance to crushing of 250 tons showed signs of buckling when the yacht was being sailed hard in the scend of a heavy sea. The deck is carried by the belt frames and by longitudinal lines of $1\frac{5}{8}$ bulb angles, which latter extend in unbroken lines from stem to stern, passing through apertures cut for them in the belt frames. Galvanized steel deck plating is used, and to protect it from the weather it is covered with a preparation of cork tiling which is impervious to water and at the same time adds but very slightly to the weight of the deck.

Sail plan.—From what has been said of the lowering of weights in *Constitution* and the increased power of her form, it is evident that she can swing aloft a spread of sail which will rival that of *Independence* in area. Compared with *Columbia*, the boom will be lengthened to 110 feet, about 4 feet will be added to the hoist, the fore triangle will be lengthened, as will the topmast and gaff, with the result that a total of 14,400 square feet of sail will be carried—an area which may be subsequently decreased or added to according to the ability of the boat as shown in her tuning up. All things considered, we look for *Constitution* to beat *Columbia* over a thirty-knot course by not less than ten minutes in light airs and five minutes in a breeze. This would mean an advantage of respectively eighteen minutes and eleven minutes over *Shamrock I* under the form which the latter yacht showed over here. Will *Shamrock II* display an equal superiority over *Shamrock I?*

The new cup defender will be under the management of William Butler Duncan, Jr., whose very able handling of *Defender* in the tuning-up trials of *Columbia* added greatly to the interest of the trial races of the season of 1899.

Independence.—This is the name given to the Lawson yacht, whose dimensions were given on page 321 of the last number of the JOURNAL. For a time, there was much doubt that she would compete with the *Columbia* and the *Constitution* during the trial races, Mr. Lawson being unwilling to transfer her to a member of the New York Yacht Club; but the matter has been satisfactorily settled by Mr. Lawson agreeing to charter an interest in her to a member of that club. The "Scientific American" has

published a complete description of her, which is here reproduced for comparison with the *Constitution*.

Length over all, feet and inches	140–10½
on water line, feet	90
Overhang forward, feet and inches	27– 5½
aft, feet and inches	23– 5
Beam, extreme, feet and inches	23–11½
at water line, feet and inches	23– 5
Draught, extreme, feet	20
Freeboard at stemhead, feet and inches	6–11
at taffrail, feet and inches	4– 8
least, feet	4
Deck beam at forward end of waterline, feet	15
at after end of waterline, feet and inches	18– 9
Beam at taffrail, feet and inches	11– 8
Area of lateral plane, square feet	772.6
of midship section, square feet	117.9
of L.W.L. plane, square feet	1,771.5
Wetted surface, with small rudder, square feet	2,913.5
large rudder, square feet	2,956
Displacement, tons	146.75

Assuming that the new defender which Herreshoff is building will be an improved *Columbia*, as *Columbia* was an improved *Defender*, it is interesting, with the plans of the Lawson boat before us, to compare the points of difference between *Independence* and *Columbia*. In the first place, comparing the midship section, the *Independence* has a harder bilge, a flatter floor and the curve at the garboards is of much smaller radius; in these respects, indeed, she is not unlike the *Shamrock*. As we leave the midship section, the difference between *Independence* and *Columbia* becomes very marked. In the *Columbia* the bilges begin to ease away rapidly toward the bow until at the forward end of the water line the cross section of the bow approximates a blunt V form, thus giving a sharp and easy entrance and water lines that do not lengthen much as the boat heels to a breeze. Aft of the midship section the run and quarters of the *Columbia* are remarkably fine and easy, and although in a breeze she lengthens her water line almost to the taffrail, the form is such that there is but little perceptible drag, or quartering wave, when the vessel is reaching in a strong breeze.

The characteristics of *Independence* are her extremely long overhangs, giving her an over-all length fully 10 feet greater than that of any previous cup defender. Coupled with this great length is the fact that she carries her hard bilges and flat floor well out beyond the normal 90-foot mark, both forward and aft, thus providing an extremely long, flat floor and a great gain in water-line length when the boat is heeled. With this form of hull it is possible to carry a maximum amount of sail with a minimum amount of ballast, and as a matter of fact *Independence* will carry only 75 tons of lead in her keel as against the 85 to 90 tons which are generally credited to the *Defender* and *Columbia*.

Perhaps the best idea of the full bow and stern sections and natural sail-carrying power of the yacht is derived from a consideration of the load-water-line plane, and the views of the interior of the hull looking toward the bow and toward the stern from the mast step. Here it will be seen how the flat floor extends practically the whole length of the yacht, the hard curves at the bilges being maintained well into the bow, and carried out to the 79th or last frame. Although there will be a certain bluffness in the bows, it must be admitted that once entrance has been made, the lines of the yacht will be such as not merely to provide great sail-carrying power, but a form which will lend itself to high speed. Even when driven to the limit, the *Independence* should leave a wonderfully smooth wake behind her. Two rudders are provided; the after rudder will be used in place of the forward one, if the sailing trials prove that its more powerful control is necessary.

Considered from a structural standpoint, the new yacht shows how the principles of framed structures, as used by the engineer in bridge building, are being applied to yacht construction. The peculiar model of *Independence*, with her great overhangs and shallow depth, renders the task of meeting and distributing the intense local strains which are set up in the structure of such an extreme racing yacht most difficult. For instance, the mast is stepped fully 10 feet forward of the stem, and at a point where the molded depth of the boat is not more than 4 feet and the

draught 2 feet. Upon the thin bronze bottom of the boat, which at this point is less than ¼ of an inch in thickness, is to be carried the enormous vertical load of the mast with its towering structure of spars, canvas and rigging, a load which is intensified by many tons when the vessel is heeled to a breeze, and the vertical component of the pull of the shrouds is added to the normal dead load of the mast. This vertical thrust is met by interposing between the heel of the mast and the plating of the hull a deep, cellular structure of steel plates, which measures 12 feet in width by 14 feet in length, and is 2½ feet deep at the center. This structure is riveted upon the frail floor of the boat, and serves to distribute the load of the mast throughout the surrounding framework of the hull. Associated with the mast foundation is a series of four special, transverse, deck beams, extending across the deck in the wake of the mast, which are in reality bowstring trusses, 17 inches in depth at the center, of great vertical stiffness. From the bottom of these trusses a number of ⅞-inch steel tie rods are carried down through the steel ring which forms the step of the mast and secured by nuts below the bottom face of the same, thereby transmitting a portion of the mast load directly to these deck beams. Moreover, the special deck beams above mentioned and the mast-step framing are connected by a system of trussing, composed of 2⅜-inch hollow-steel struts and 3 by 3-inch angles. As the transverse strains which are set up at this point in a racing yacht when she is being pressed to the utmost in a strong breeze are enormous, not only is there the great downward thrust of the mast, as above explained, but there is the upward pull of the shrouds on the side of the boat which in itself will run up to the total of a great many tons. The deep deck beams and the cellular structure of the mast step, with the triangular bracing of the angles and struts, together constitute a true bridge structure, admirably adapted to take care of the intensified local stresses at this point, and distribute them over a broad area of the delicate shell of the yacht.

Another interesting study is the provision made for giving the necessary longitudinal strength to the long, overhanging bow

and stern of *Independence*. There is a deep, vertical keel-plate which varies from a depth of 9 inches at the bow to 18 inches at the point where the fin keel commences. At the center line of the deck there is also a horizontal steel plate of the average width of 18 inches associated with the vertical plate which is from 6 to 8 inches in depth. Between these two members, which might be called the top and bottom chords, there is worked in a system of tie-rod bracing and vertical, hollow-steel struts, the rods varying from $\frac{7}{8}$ of an inch to 1 inch in diameter, and the struts from $1\frac{1}{2}$ inches to 2 inches in diameter. This construction provides what is practically a deep steel truss, which extends from the stiffened framing at the mast out to the end of the overhanging bow. The necessity of trussing of this kind will be appreciated by those of us who remember what happened to the over-lightly built bows of the 70-footers of last season, which, yielding to the enormous upward pull of the head stay and topmast stay, were drawn upward out of their proper line from 12 to 14 inches. The after overhang is similarly trussed, the tie-rod bracing, however, running only in one direction, that being put in, doubtless, to assist in carrying the weight of the crew when it is massed toward the taffrail to keep the bow of the boat up when she is running before the wind. The hull is further stiffened by four lines of stringers, two on each side, with 2-inch tubular struts extending from the stringers to the deck beams.

There are 79 frames in the yacht spaced about $2\frac{1}{2}$ feet apart. The frames consist of nickel-steel angle bulbs. The plating of the hull is of bronze from the keel to the sheer strake, which latter is of steel. From amidships to a little forward of the mast the sheer strake is $\frac{9}{32}$ of an inch in thickness, while from forward of the mast to the bow it is $\frac{1}{4}$ of an inch, and from amidships to the stern it is $\frac{1}{4}$ and $\frac{3}{16}$ of an inch in thickness. From the garboard strake to the sheer strake the bronze plating is $\frac{7}{32}$ of an inch, and $\frac{1}{4}$ of an inch in thickness amidships and $\frac{3}{16}$ of an inch thick forward and aft. From the garboard strake to the bottom of the keel the bronze plating is $\frac{1}{4}$ of an inch and $\frac{5}{16}$ of an inch in thickness, while the bottom plate of the keel is a bronze casting

$\frac{5}{8}$ of an inch in thickness. In constructing the yacht the keel was first built up and riveted, and then pig lead, with shot to fill up the interstices, was stowed, until 62 tons of the same was in place. Molten lead was then run over the top to form a crust, and keep it in place. After the yacht is afloat, about 13 tons of pig lead will be stowed above this until the vessel has reached the desired trim. The deck beams are angle bulbs of the same weight as the frames. The deck plating is of steel and aluminum, distributed as follows: Continuous steel side stringers run from stem to stern, and vary in diameter from $\frac{3}{16}$ by 10 inches at the ends, to $\frac{1}{4}$ inch by 2 feet in width amidships. There is also the longitudinal centerline steel plate, already referred to, which varies from $\frac{1}{4}$ inch by 2 feet amidships to $\frac{3}{16}$ of an inch by 1 foot in the ends. The deck is covered with $\frac{3}{16}$ of an inch steel plating for a distance of 10 feet forward and aft of the mast. The rest of the deck is plated with aluminum. As the displacement of *Independence* is given as $146\frac{3}{4}$ tons and the total lead ballast will amount to about 75 tons, it is fair to presume that the total weight of the hull, spars, rigging, sails, stores and crew, when the boat is down to her 90-foot water line, will be about 72 tons.

There can be no question of the great originality and skill with which the construction of this interesting boat has been worked out. The peculiarity of her form, her great sail-carrying capacity, involve that she will be put to severer strains than any yacht of her size that has yet been launched; and we think that the designer is to be congratulated upon the success with which he has combined lightness and strength in producing a powerful form. Had the *Independence* been built upon what might be called the commonly-accepted lines of a 90-footer, and had there been less originality shown in the design, there would not be the great public interest attending her trials against the Herreshoff boat which is now certain to be manifested.

Lysistrata.—The new steam yacht built by Denny Brothers for Mr. James Gordon Bennett, from the design of Mr. Geo. L. Watson, ran her steam trials on the Firth of Clyde early in

March, and for six hours averaged 19.21 knots. Her dimensions are:

Length over all, feet	314.42
on waterline, feet	285
Breadth, extreme, feet	39.75
Tonnage, Thames measurement	2,082
I.H.P., forced draft	6,500

Her external appearance is quite different from that of the orthodox yacht. She has a straight stem, a short turtle back forward, a single mast, which is located abaft the smoke pipe and used only for signalling, and two deck houses. The stem ends in the figure of an owl with wings extended, the eyes of which are fitted with electric lights which show off the forward part of the yacht to great advantge at night. The internal arrangements and decorations are, of course, on a scale in keeping with the size and speed of the yacht.

Her twin-screw engines are of the triple-expansion type, each with four cylinders 23, 38 and two of 42 inches diameter and 30 inches stroke. Steam is furnished by four single-ended boilers 15 feet 9 inches diameter and 11 feet 6 inches long, containing 342 square feet of grate and 9,804 square feet of heating surface. She has also an auxiliary boiler. The screws are 11 feet 6 inches diameter.

The following are the results of her coal-consumption trial, which took place on the 14th of March:

Duration of trial, hours	11.5
Speed, knots	14.4
Revolutions per minute	103.35
Steam pressure in boilers, pounds	195
I.H.P. of main engines	*2,099
one feed pump	11
two circulating pumps	28
total	2,138
Coal per hour (less allowance for one dynamo engine at the rate of one ton a day), pounds	3,265
I.H.P., pounds	1.53

* Mean of four sets of diagrams.

The coal was selected Welsh, and the firing skillfully done Her bunker capacity is 500 tons.

Orienta.—On April 27, there was launched from the Crescent Shipyard of Mr. Lewis Nixon, at Elizabeth, N. J., a steam yacht of the following dimensions for Mr. Edward R. Ladew:

Length, feet	101.5
Beam, feet	12
Draught, feet	5

In outward appearance, she bears a striking resemblance to a torpedo boat, and were it not for the large dining room forward, and being painted white, might easily be mistaken for one. She will be schooner rigged. She has a comparatively large forecastle, and back of this a room for the captain and engineer. Then comes the galley, after which are the fire room, coal bunkers and engine room. Abaft of these is the owner's quarters, a large double stateroom, extending across the vessel, with bath room adjoining. There is a large-sized saloon and toilet room, with two staterooms further aft.

All the woodwork is of mahogany, with silk and tapestry panels. The headroom is over 7 feet. On deck there is the dining room forward, 15 feet long, with a pantry adjoining. The after deck is unbroken, except for a large divan aft.

The vessel will be driven by a triple-expansion engine, with cylinders 10 inches, 15 inches and 25 inches in diameter by 15 inches stroke, and of 600 horsepower. The boiler is of the latest type of the Mosher water tubular, with 40 square feet of grate surface. A large blower is fitted in the deck to deliver air under forced draft into the fire room. An electric plant, a fresh-water plant and all the various auxiliaries making up the perfect yacht will be found in this boat.